ENGINEERING NEWS

AND

AMERICAN RAILWAY JOURNAL.

Vol. XXXI. No. 10.

TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 189

Third Ave. (N. Y.) Cable Railway (*with inset*)..... 190
Sewage Purification in America (*illustrated*)..... 190
Recent Types of Street Car Fenders (*illustrated*)..... 193
Test of a Dredge, Mississippi River Commission..... 194
Steam Distribution for High Speed Locomotives (*illustrated*)..... 195
Earth Dams and Reservoir Embankments..... 203
Edmund Gunter..... 198
The Galveston County (Tex.) Highway Bridge (*illustrated*)..... 204
The Sewerage System of Oberlin, O..... 204
The Electric Station of the Citizens' Light & Power Co., Rochester, N. Y..... 205
The Laredo Water Tower (*illustrated*)..... 206

PERSONALS, NEW PUBLICATIONS, SOCIETY PROCEEDINGS..... 198

EDITORIAL NOTES..... 200

Iron and Steel Production and Prices in the United States—Discrimination Under the Interstate Commerce Law—The Economy of High Train Speeds—Steam Distribution in the Locomotive—Importance of Increased Appropriation for U. S. Timber Tests—Greater New York.

EDITORIAL..... 201

The Prevention of Collisions on Street Railways.

LETTERS TO THE EDITOR..... 202

Long Plate Girder Bridge—Errata in "Cleaning and Sewerage of Cities"—Area Needed for Sewage Disposal by Irrigation—Celluloid Scales—Tunneling Under the East River—The East Providence Stand-Pipe Failure.

CONSTRUCTION NEWS..... 287

Railways, Street and Electric Railways, Elevated and Cable Railways, Highways, Bridges, Tunnels and Canals, Water-Works, Artesian Wells, Irrigation, Sewers, Streets, Electric Light and Power, Contract Prices, Miscellaneous Contracts and Supplies.

The Love electric conduit street railway, which has been in operation for more than a year on a considerable portion of the Rock Creek Ry., in Washington, D. C., had a severe test during the recent heavy snowstorms. Contrary to the prophecies of many of its opponents, the underground section of the road worked admirably all through the storm, while that portion of the line operated by overhead wire was badly crippled. The streets were filled with snow and slush, but the conduit which contains the trolley wires is well drained, and the result showed that the loss from these wires by leakage was much less than the loss from the overhead wires on the same road. This is in marked contrast to the theories and statements put forth by Mr. Albert Stetson, printed in our issue of Jan. 25.

The railway corporations of Pennsylvania are thus enumerated by Secretary Stewart, of the Department of Internal Affairs of that state in his last report: Steam railways in operation, 261, and 16 in process of construction; 124 street railways, and 196 under construction or seeking authority to construct; 9 canals and 26 telegraph or telephone companies; a total of 722 corporations in this one state of the character described. In view of the mass of work thus entailed Mr. Stewart recommends that the next legislature provide for a railway bureau in his department and the appointment, of a chief with a salary commensurate with the high degree of efficiency required in so responsible an officer. He also recommends a sharper supervision of the management and equipment of these railway corporations with regard to the safety of employees and passengers. Pennsylvania has no railway commission, as it has been held that the state constitution practically imposes the duties of such a commission upon the Secretary of Internal Affairs. It is with this decision in view that Mr. Stewart properly asks for a broader organization of his department and the requisite authority to inspect and pass judgment, through experts, upon the safety of bridges, roads and equipments.

A supplementary report on the use of metal ties for railway track is being prepared by Mr. E. E. Russell Tratman, of New York, to accompany the third edition of his original report issued by the Forestry Division of the U. S. Department of Agriculture in 1890. The supplementary report will bring the information and statistics as nearly up to date as possible. It will deal also with the use of preservative processes for wooden ties and with the advantages of metal tie plates for protecting wooden ties. While the use of metal ties is steadily increasing in many countries and is likely to increase in this country in the future, yet under our present conditions of timber supply and railway finances, the adoption of means to increase the durability of wooden ties and to enable certain inferior species of timber to be successfully utilized, are more important subjects for immediate consideration, and as a general thing railway managers have not recognized the important economy and efficiency to be realized by the use of preservative processes, metal tie plates and improved rail fastenings. According to Mr. Tratman's original report, made in 1890, and reviewed in our issues of Aug. 30, 1890, and Aug. 15, 1891, the use of metal ties in 1889 was practically nil in the United States and Canada. In the remaining countries of the world, there was a total railway mileage of 187,721 miles, of which about 25,000 miles, or 13%, were laid with metal ties.

The strange ideas of English locomotive builders that railways must be built to carry the locomotive instead of the locomotive built to run on the railway have been again illustrated in the case of some engines for India. "Herapath's Railway Journal" has the following paragraph, and India and Australia have had similar experience before:

Certain new engines recently sent out for the South Indian Ry. were so much overweight that orders had to be issued restricting their speed over bridges to walking pace, and the following explanation of the matter has been published. The maximum weight sanctioned by the Indian Government on a pair of meter gage locomotive engine wheels is eight tons. In 1892 government sanctioned the addition of 20 locomotives to the South Indian Ry. Co.'s stock, and when these engines were constructed in England, through an oversight, a weight of nine tons was placed on the driving wheels. The engines were duly received in India, and have been working during the last nine months. In September last the locomotive superintendent brought to the notice of the company's agent that the maximum sanctioned weight on a pair of wheels had been exceeded, and accordingly the agent applied to the consulting engineer for railways to obtain the sanction of government to allow the standard weight to be increased in the case of these engines. The subject, which has been under correspondence since then, has culminated in the consulting engineer for railways requesting the agent, pending the decision of government on the matter, to restrict the speed of these engines to walking pace over girder bridges.

A code of rules to govern architectural competitions is to be prepared by a committee appointed by the American Institute of Architects, consisting of Messrs. Geo. B. Post, Jas. W. McLaughlin and Thos. Hastings. A general invitation is extended to architects by the committee to submit suggestions for its consideration.

The most serious railway accident of the week was the derailment of an express train on the Pennsylvania R. R. near Columbus, O., March 6. Three trainmen were seriously injured.——A fast double-header southbound train of mail and express cars on the New York Central R. R. was derailed near Scarborough, N. Y., March 1. The coupling between the engines broke and the front engine ran ahead and was then run into by the second engine, the shock derailing the latter, which fell into the river. Two men were injured, but not seriously.——On the Brooklyn Elevated R. R. nine rear collisions of consecutive trains occurred in the fog on March 2, and the engines and cars were more or less injured. No flagmen were sent back, and further repetition of the collisions was finally prevented by a city fireman walking back and waving his red-lined overcoat.

The boiler of a freight locomotive on the Baltimore & Ohio R. R. exploded at Nuzums Mills, W. Va., Feb. 28, injuring two men. The engine was standing on a sidetrack.

A trestle carrying the Mississippi River & Bonne Terre Ry. across Swashin Creek, near Herculaneum, Mo., gave way under a freight train March 1. One man was killed and three were injured.

An electric car ran away on the Seneca St. hill at Cleveland, O., Feb. 27, and jumped the track on the Seneca St. bridge at the foot of the hill, colliding with one of the posts of the truss. Nobody was injured, but the front end of the car was wrecked.

Double-decking the Manhattan Elevated system, in New York, is to solve the problem of rapid transit in that city, says Mr. Russell Sage. According to the same authority plans are completed "by one of the most distinguished engineers in the country," but no detail is yet given out. It is intimated that the second story of two tracks, to be used for express service, is to have its own separate supports, and that the two lines of track will be completed and substantially tied together without interfering with traffic. No date for beginning is mentioned, but if the scheme is carried out some interesting engineering work will be necessary.

A scheme for a Greater Boston is before the Massachusetts Legislature, proposing to annex all the towns within a radius of 14 miles of the State House and give the city a total population of 900,000.

The scheme of the Brooklyn Elevated Railroad Company, proposing to run on a second story track across the Brooklyn bridge, is strongly opposed by Col. Washington Roebling, at one time Chief Engineer of the bridge. In a conference with Mr. C. C. Martin, the present Chief Engineer and Superintendent of the bridge, Colonel Roebling said that the track proposed would unduly strain the bridge by presenting a much greater surface to the wind during gales, and it would also completely shut out the view from the promenade for foot passengers.

A complete congressional investigation of the affairs of the Nicaragua Canal Co., looking to government control of the canal, is called for in a bill introduced into Congress by Mr. Geary, of California. The bill provides for a special committee of five members of the House. Mr. Geary believes that the government should buy out all existing rights and build the canal.

The Dismal Swamp Canal, one of the oldest waterways in the country, is to be widened and deepened to 10 ft. and the dredges for this purpose are now being built at the village of Deep Creek, near the north outlet of the canal. It is expected that the work of improvement will commence in May. The old stone locks are also to be widened.

Beds of sawdust from 40 to 50 ft. deep are making trouble for the engineers who are preparing plans for the foundations for the new interprovincial bridge over the Ottawa River in Canada. Soundings show that above these sawdust beds there are 50 ft. of water. As the masonry is to extend above 40 ft. above the water line very deep foundations and high piers will be necessary. It is expected, however, that plans will be ready for presentation to the Dominion Parliament in about one month.

The Philadelphia Electric Elevated Railway ordinance has passed the Councils and is signed by the Mayor. The way is now open for the construction of an elevated railway in that city from Market St. to the northern part of the city.

The Nicaragua Canal question is to be taken up by the Senate Committee on foreign relations during this session, say Washington dispatches. The bill to be considered is that of Senator Morgan, already given in detail in these columns. The late Senate inquiry into the Hawaiian controversy developed the fact that both Senators Morgan and Frye are anxious to promote the canal, and their questions regarding Hawaii showed what they considered as the intimate relation between these islands and the opening of a canal across Nicaragua under American control.

The London & Northwestern Ry. has adopted a green light for a safety signal in place of a white light, which it has always used heretofore. The change will be made gradually and notices will be issued to the employees from time to time as the change is completed on each section of the line. The Caledonian Ry. has also made the same change.

The traffic on the Manchester Ship Canal, for the week ending Feb. 23, amounted to 30 vessels arriving and 29 departing. The tonnage is not stated. In the same period 77 vessels entered the Liverpool docks with an aggregate tonnage of 91,410 tons. For the year 1893 the Liverpool entries numbered 533 ships, with a total tonnage of 772,926 tons, an increase of 35 ships and 107,516 tons over the entries for the preceding year. The outward bound Liverpool vessels for the same week numbered 67, with an aggregate of 99,245 tons.

The value of the plant of the National Water-Works Co., of Kansas City, Mo., has been fixed at $2,546,112 by Messrs. Jas. Andrews and Robt. Moore, M. Am. Soc. C. E., commissioners recently appointed by the U. S. Circuit Court. The works may be purchased by the city in accordance with this appraisal, but this has not yet been determined.

The work of deepening the harbor of Philadelphia, now being done by the American Dredging Co., has progressed faster than was expected, says the Philadelphia "Record." The Board of Harbor Commissioners has notified Director Windrim that the Secretary of War has authorized, after May 1, 1894, the extension of all the piers along the Delaware, between Moore and Otis streets, out to the new pier head line on the plans prepared by Major Raymond, U. S. Engineer Corps. The American Dredging Co., on Jan. 31 last, had removed 2,955,000 cu. yds. of the 3,000,000 cu. yds. called for in their contract and are four months ahead of time. Nine dredges have been at work all winter at Petty's Island, and five more are digging away at Smith's and Windmill islands. The ultimate object is to obtain an area in front of the city 1,000 ft. wide and having 26 ft. of water.

The drainage system for the City of Mexico, described in our issue of Aug. 10, 1889, is nearing completion, and in 18 months it is expected the 36-mile canal and 6-mile tunnel will be finished, opening an outlet for the waters of the valley. The tunnel is reported at nine-tenths completed, and but 15% of the canal remains to be dug. The present work practically started in 1885, when a commission took control, and in 1887 placed a loan of £2,400,000 in London to be expended on this work. Mr. Robert Gayol, M. Am. Soc. C. E., and City Engineer of Mexico, has had much to do with the successful engineering of this great work. One peculiar feature of the financial part of the scheme is the statement that the $120,000 per month devoted to this work is raised from concessions for holding bull-fights in the City of Mexico.

THE THIRD AVENUE CABLE RAILWAY, NEW YORK CITY.*

III.

(With inset.)

The principal features of the track construction on the Third Ave. cable railway have been described in our issues of Dec. 13 and 20, 1890, and Feb. 1 and 22, 1894, and in this issue we continue the description of the work with illustrations of the large deflecting sheave vaults at the power stations and the Sixth St. terminal, and of some of the details of the pulley bearings and fixtures.

Large Wheel Vaults.—The general plan of the large wheel vault at the Sixty-fifth St. power station was shown in our issue of Feb. 1, which also showed the positions of the several deflecting sheaves and the routes of the cables into and out of the station. A number of sections of this vault are shown in Fig. 1 on our inset sheet. This vault is 146 ft. long, 60 ft. wide and 20 ft. deep and provides for eight 15-ft. deflecting sheaves. The sidewalls are built of brick masonry and the floor is of concrete. The roof consists of brick arches between I-beams, which rest on I-beam girders carried on latticed channel columns. As will be noticed, the columns of the elevated railway coming over this vault are supported on brick masonry or concrete piers resting on the floor of the vault. In addition to building these new foundations for the elevated railway columns, considerable other reconstruction of old structures was found necessary. Perhaps the most important of these was the lowering of a 30-in. water main 12 ft. below its original level for a distance of 450 ft. and inclosing it in a special tunnel so that it could be inspected. To drain the vault a special sewer was constructed leading into and through Sixty-fifth St. The floor of the vault has an inclination of 3 ins. to allow of drainage into this sewer.

The vault at Bayard St. (Fig. 2) is considerably smaller than that at Sixty-fifth St., but owing to the obstructions encountered and to the fact that the excavation of the vault and for the basement of the power station was in quicksand, the work was much more difficult. In excavating for the vault, five 16-in., two 12-in., and one 8-in. gas mains, one 20-in. water main, an electric subway, several 6-in. pneumatic tubes and a sewer were encountered and had to be lowered without interfering with their use. Several elevated railway column foundations had also to be rebuilt. On account of the quicksand these foundations had to be carried down 45 ft. below the street surface. In making the excavation for the power station foundations considerable more difficulty was had from the quicksand. The bottom of the excavation was 42 ft. below the street surface and below the water line. The method of excavating was to shore up the banks with heavy timbers and pump the seepage water. This work had to be done very carefully in order to protect the walls of the adjoining buildings from damage.

The vault at Sixth St. containing the terminal sheaves for the north end of the City Hall section and the south end of the middle section is shown in plan and elevation in Fig. 3. Beyond rebuilding the foundations of the elevated railway columns no extra work of much moment had to be done here. At the northern terminal vault, at 130th St., the excavation was below high water in the Harlem River and was divided by a large sewer which had to be preserved intact. No large obstructions were met with at the southern terminal vault, near the Post Office, but on account of the heavy street car and vehicle traffic at this point the excavation was carried on underneath a bridge of timbers over which the street traffic was carried. This same method of excavation was adopted for the regular conduit construction for most of the distance from Chatham Square to the southern terminus, including the terminal loop. Where necessary, air for the support of the workmen was forced into the excavation by hand blowers.

Besides rebuilding the various elevated railway column foundations, sewers, gas and water mains, etc., at the wheel vaults, similar reconstructions had to be carried out at various points along the regular conduit construction. Among the more important of these may be noted the rebuilding of a nest of five large water and gas mains which crossed the line diagonally and continued parallel to it for several hundred feet at a point near Fifth St., on the Bowery. These were all lowered, the gas mains renewed and the water mains placed in a brick subway of sufficient size to allow of access for inspection. Another considerable piece of new work was the rebuilding of a number of sewer manholes which came directly in the line of the track on the Bowery. Here the brick shaft was removed down to the line of the sewer and then a transverse vault was built of sufficient length to bring the manhole outside the line of the tracks. A new shaft was then built to this vault. This work was very troublesome, as the excavation was mostly in sand, which necessitated shoring up the sides during construction. Besides these large mains, small gas and water pipes were encountered at numerous points along the line and had to be lowered or otherwise arranged for.

Gimbal Bearings.—As stated in our issue of Feb. 22, the spiral curve pulleys are hung on gimbal bearings to permit of adjustment in any direction. Details of the upper and lower gimbal bearings for the curve pulleys on the Chatham Square curve are shown in Figs. 4 and 5, and in Fig. 6 are shown the details of the gimbal bearings for one of the 6-ft. deflection sheaves at the Sixth St. wheel vault. All parts of these bearings except, of course, the brass bushings are of steel. Fig. 7 shows a gimbal bearing for a 15-ft. sheave, of which 20 are in use at the Bayard St., Sixth St. and Sixty-fifth St. wheel vaults. These illustrations show the construction of the gimbal bearings so clearly that no further description is necessary.

(* Copyright, 1894, by Engineering News Publishing Company.)

SEWAGE PURIFICATION IN AMERICA.

(Continued from p. 87.)

Chemical Results at the Worcester Precipitation Works.

The sewage purification works at Worcester were built to lessen the pollution of the Blackstone River, which for years received the sewage of Worcester through Mill Brook. The condition of this river in 1889, a few months before the purification works were put in operation, was described in the Special Report of the Massachusetts State Board of Health on Examination of Water Supplies, published in 1890, as follows:

> The Blackstone is at the present time the most polluted river in Massachusetts, a result which is due for the most part, as already stated, to the sewage of the city of Worcester, though the pollution is increased to an appreciable extent by the sewage and waste discharged into the stream from the many factories upon it and its tributaries.
>
> The most polluted portion of the river is within a few miles of and below the point where the Worcester sewage enters it, and particularly in the town of Millbury, where there are several mill ponds which act as settling basins to retain foul deposits. In this portion of the river, and for a considerable distance below Millbury, the water is not only very offensive at times of low flow, but it is stated that it is so dirty that it cannot be used for making light-colored cloths, and is unfit for use in boilers, as it causes foaming and corrosion. The latter may be due in part to the large amount of acid used by the iron manufacturers in Worcester, some of which finds its way into the river, the water of which below Worcester has, at times, an acid reaction.

The increasing pollution of the river is shown by Table I., which gives analyses of water taken from the river in Millbury, below the point of sewage discharge. The analyses were made in 1872, 1875, 1881 and 1891, the latter after the purification works had been in operation about a year, but were purifying only part of the sewage. The figures are from the report of the Massachusetts State Board of Health for 1891.

TABLE I.—Analyses of Water from the Blackstone River, made in 1872, 1875, 1881 and 1891, Showing the Contaminating Effect of Worcester Sewage.

(Parts per 100,000.)

	Nov. 8, 1872.*	July, 1875.	Aug. 30 and Oct. 2, 1881†	July 24 and 25, 1891.
Total residue on evaporation.	6.2	8.04	13.15	28.5
Loss on ignition	...	....	3.55	7.5
Fixed residue	...		9.8	21.
Free ammonia	0.045	0.0992	0.0794	0 670
Albuminoid ammonia	0.04	0.0307	0.1176	0.106
Chlorine	1.2	0 92	2.4	2.85

* Collected just after heavy rain. † Average of two analyses.

Above the point where the sewage is discharged the river has a drainage area of about 60 sq. miles, 12½ miles of which is tributary to Mill Brook. This brook in an ordinary year may be assumed to have a natural daily flow of 12,500,000 gallons, according to the report of the Massachusetts State Board of Health for 1890. Of course the natural summer flow of the brook is much below this figure, but owing to the many storage ponds on the stream and the use of the water for manufacturing purposes the summer flow is both larger and more uniform than it would be otherwise.

All the sewage of Worcester is discharged into this stream, reaching the Blackstone River in this manner, but since the chemical precipitation works were put in operation on June 25, 1890, varying proportions of the combined sewage and water have been diverted from the brook just above its junction with the river and subjected to purification. From July 15 to Nov. 30, 1893, it is stated that the whole flow of water and sewage in Mill Brook was so treated.

The population of Worcester was 84,655 in 1890, having increased to that figure from 58,291 in 1880. The water supply is by gravity from impounding reservoirs on the headwaters of the Blackstone River. The average daily water consumption for the three years 1888, 1889 and 1890 was 4,635,000, 4,753,680 and 4,971,340 gallons, respectively, the consumption for 1890 averaging 59 gallons per inhabitant, 89.4% of the taps having been metered.

The Massachusetts State Board of Health has made careful studies of the Blackstone River for many years, and since the Worcester purification plant was put in operation special attention has been given to its effect upon the stream. But the

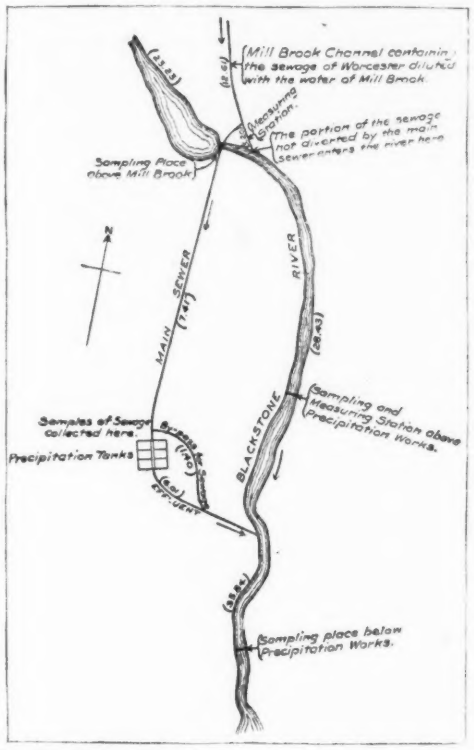

(Mill Brook Channel containing the sewage of Worcester diluted with the water of Mill Brook.
Measuring Station.
The portion of the sewage not diverted by the main sewer enters the river here
Sampling Place above Mill Brook
N
MAIN SEWER (7.61)
RIVER
(68.83)
Sampling and Measuring Station above Precipitation Works.
Samples of Sewage collected here.
Screens
Precipitation Tanks
Final Effluent
BLACKSTONE
(38.80)
Sampling place below Precipitation Works.

Fig. 99. Sketch Showing Location of Worcester Precipitation Works in Relation to Blackstone River and Mill Brook.

success of the works can be gaged only in part by the results of these studies, for two reasons: (1) Until July 15, 1893, only a portion of the sewage was treated; and (2) if all sewage, including even the purified effluent, were excluded from the river, it would be some time before the stream would regain its former condition, owing to the deposits of organic matter in the bed of the stream and in the numerous millponds along its course. This point will be discussed further on.

With these limitations in mind there may be considered a special study made by the above-named board during the week ending July 29, 1891. The general plan of these studies was given in the report of the board for the year 1891, as follows:

> This examination was made during a very dry part of the summer of 1891 and was continued day and night during the week ending July 29. It included chemical, and in many cases microscopical, examinations of water from the river at several points and from its principal tributaries; chemical examinations of sewage and effluent from the Worcester precipitation works, and measurements of the flow of the river, of sewage turned directly into the river and of sewage treated at the precipitation works.
>
> Special precautions were taken to obtain samples which would accurately represent the average character of the sewage, effluent and river water. In the case of the sewage one bottle was filled for chemical analysis every six hours, but instead of filling it wholly at one time its contents were made up of 12 equal

half-hourly collections. The number of analyses of sewage made during the week was 28, representing in all 336 portions of sewage. The same number of samples of effluent were collected and in the same way, but as the amount of sewage then being treated required six hours for its passage through the tanks the samples of effluent were taken six hours later than the corresponding samples of sewage. The samples of sewage were collected from the mouth of the main sewer

TABLE II.—Analyses of Sewage and Effluent from the Worcester Precipitation Works During the Week Ending July 29, 1891.

	(Parts per 100,000.) Sewage.	Effluent.	Per cent. decrease or increase.
Color	0.28	0.14	— 50
Residue on evaporation..	92.86	52.65	— 43
Dissolved	44.13	46.64	+ 6
Suspended	48.73	6.01	— 88
Loss on ignition	28 31	12.60	— 56
Dissolved	13.29	11.28	— 15
Suspended	15.02	1.32	+ 91
Fixed residue	64.55	40.05	— 38
Dissolved	30.84	35.36	+ 15
Suspended	33.77	4.69	— 86
Free ammonia	1.2684	1.1829	— 7
Albuminoid ammonia ..	0.4509	0.1994	— 56
Dissolved	0.1510	0.1588	+ 5
Suspended	0.2999	0.0406	— 86
Chlorine	5.33	4.77	— 11
Nitrogen as nitrates	0 0575	0 0542	— 6
Nitrogen as nitrites	0.0103	0 0562	+446
Oxygen cons'md, unfil't'd	4 9126	1.0583	— 78
Filtered	1.5728	0.8116	— 48
Iron oxide (Fe_2O_3)	10.75	0.41	— 96
Lime (CaO)	3.33	12.74	+283
Sulphuric acid (SO_3)	14.84	15.66	+ 6
Bacteria per cu. cm*....	209,592	14,458	— 93

* The bacteriological examinations were made Sept. 15, 1891. The number of bacteria in the sewage, as above given, is the average of two determinations made with samples of ordinary sewage. One sample, collected when there was much iron in the sewage, contained only 18,900 bacteria per cu. cm. This sample was very much infested with molds. The number of bacteria in four samples of effluent varied from 9,016 to 20,882. The gelatine plates of all of these samples were prepared on the spot, immediately after taking the samples.

above the screens and above the point where the chemicals are mixed with the sewage, and the samples of effluent from the weir where the sewage flowed from the last tank.

In collecting the samples from the river above and below the precipitation works the same general plan was followed as in the collection of the sewage and effluent, except that three samples instead of four were collected each 24 hours and they were made up of only two or three equal portions. From other points on the river and its tributaries only one sample a day was collected, but wherever it was feasible this sample was made up of from two to four equal portions. The total number of samples analyzed in connection with this examination was 136.

The character of the Worcester sewage and the purification works has been described in previous numbers of this journal (Nov. 15 and 22, 1890, July 28, 1892, and Jan. 11, 18 and 25, 1894). During the special study an average of 6,010,000 gallons of sewage was treated daily, and 6,600,000 gallons per day passed to the river without treatment. The average amount of sewage treated during the year ending Nov. 30, 1891, was about 3,833,000 gallons per day. The 6,010,000 gallons treated daily during the special study was really more than the works could handle to the best advantage. During the week in question 33.66 net tons of lime and 7.11 tons of sulphate of alumina were used, which was at the rate of 1,600 lbs. of lime and 340 of sulphate of alumina per million gallons, against about 1,080 lbs. of lime and 90 lbs. of sulphate of alumina for the whole year. The sewage at Worcester, as has been stated, is diluted with the water of Mill Brook. During the week the flow of the Blackstone River, above Mill Brook, or the point where it receives the Worcester sewage, was 23,230,000 gallons per day, or about twice the total flow of Mill Brook, water and sewage combined, and less than four times that part of the flow of Mill Brook which was discharged into the river without purification. This emphasizes point (1), above, since for every gallon of sewage treated more than a gallon of unpurified sewage passed into the river, and that at a time when the works were being operated at a rate higher than the average.

The location of the purification works in relation to the brook and river, the average daily flow of each and the amount of sewage and water diverted by the main sewer from Mill Brook and either passed through or around the works, are shown by Fig. 99 (not drawn to scale), the figures in parentheses being millions of gallons. The sketch is taken from the report of the board for 1891.

The average results obtained by chemical precipitation during the week is shown by Table II., analyses of sewage and effluent, and per cent. increase or decrease.

Both the loss on ignition and albuminoid ammonia show a total reduction of 56%, the suspended matter decreasing 91% on ignition and the dissolved, 15%, while the suspended albuminoid ammonia decreased 86% and the dissolved increased 5%. The oxygen consumed decreased 78% for the unfiltered and 48% for the filtered samples. These determinations indicate the amount of organic matter removed and thus the degree of purification attained.

Analyses of water from the Blackstone River above Mill Brook channel, between the channel and the precipitation works and below the works, show the pollution caused by the sewage. These figures are combined in Table III., as the first three columns, with analyses of the river water at succeeding points down the stream in order to show the improvement of the water by dilution. The first three points are within a distance of a little over a mile. The water at the upper point shows some pollution from sewage and manufacturing refuse, but not enough to render it objectionable to those living near the river. The third point was considered as the foulest in the river, although at low water the river below might be more offensive through the exposure and putrefaction of accumulated organic matter. The last four columns of Table III. show improvement of the water as the dilution increases with the added drainage area and the deposition of suspended matter and oxidation increase with the distance. The decrease in suspended residue on evaporation of from 12.2 parts at the precipitation works to 5.3 parts per 100,000 at Milbury is due to the deposition of suspended matter, as there is in this distance practically no decrease in the dissolved residue. Oxidation to nitrates is only noticeable at the two lower stations. The slight decrease in free ammonia in the upper part of the river shows "that the reduction due to dilution and decomposition is to a considerable extent offset by the further decomposition of the organic matter contained in the water or deposited upon the bed of the stream."

TABLE III.—Analyses Made During the Week Ending July 29, 1891, of the Water of the Blackstone River Above and Below the Points Where the Worcester Sewage and Sewage Effluent are Discharged.
(Parts per 100,000.)

	Worcester.			Millbury.		Uxbridge.	Millville.
	Above Mill Brook Channel.	Between Mill Brook Channel and precipitation works.	Below precipitation works.	Outlet of Morse's mill pond.	Below last dam.	Dam of Calumet, Woollen Co.	Above dam.
Area of watershed, square miles	.....	.....	64.6	70.6	83.9	145.9	158.1
Relative sizes of watersheds	.....	.....	1.0	1.09	1.3	2.26	4.0
Color	0.95	0.44	0.33	0.1	0.1	0.24	0.26
Residue on evaporation	6.94	27.84	35.89	28.5	20.6	11.07	7.49
Dissolved	.....	16.71	23.69	23.2	16.0	.....	.....
Suspended	.....	11.13	12.2	5.3	4.6	.....	.....
Loss on ignition	2.58	8.37	9.55	7.5	3.8	2.59	2.49
Dissolved	.....	5.19	5.86	5.1	2.4	.....	.....
Suspended	.....	3.18	3.69	2.4	1.4	.....	.....
Fixed residue	4.36	19.47	26.34	21.0	16.8	8.48	5.0
Dissolved	.....	11.52	17.83	18.1	13.6	.....	.....
Suspended	.....	7.95	8.51	2.9	3.2	.....	.....
Free ammonia	0.0166	0.2699	0.6233	0.607	0.501	0.2506	0.873
Albuminoid ammonia	0.0489	0 1168	0.1869	0.106	0.059	0.0345	0.0214
Dissolved	0.0318	0.0415	0.078	0.042	0.028	0.0271	0.0163
Suspended	0.0171	0.0753	0.1089	0.064	0.031	0.0074	0 0051
Chlorine	0.27	1.67	2 48	2.85	1.71	0.87	0.52
Nitrogen as nitrates	0.0117	0.0134	0.0115	0.005	0.007	0.0043	0.0359
Nitrogen as nitrites	0.0001	0.0026	0.0052	0.0	0.0001	0.0004	0.0002
Oxygen consumed, filtered	0.703	1.3241	1.7809	1.0455	0.583	0.133	0.427
Unfiltered	.....	0.4216	0.6606	0.593	0.4705	0.117	0.273
Iron oxide (Fe_2O_3)	0.36	4.45	3.52	3.87	1.0	0.17	0.12
Lime (Ca O)	0.77	1 6	4.33	4.39	3.63	1.99	1.12
Sulphuric acid (SO_3)	0 80	5 39	7 62	9 3	7.15	3.43	1 75
Bacteria per cu. cm.*	77,750	47,550	16,650	84,500	.....	.....	.....

* The bacteriological examinations were made Sept. 15, 1891, and the results are the average of two determinations.

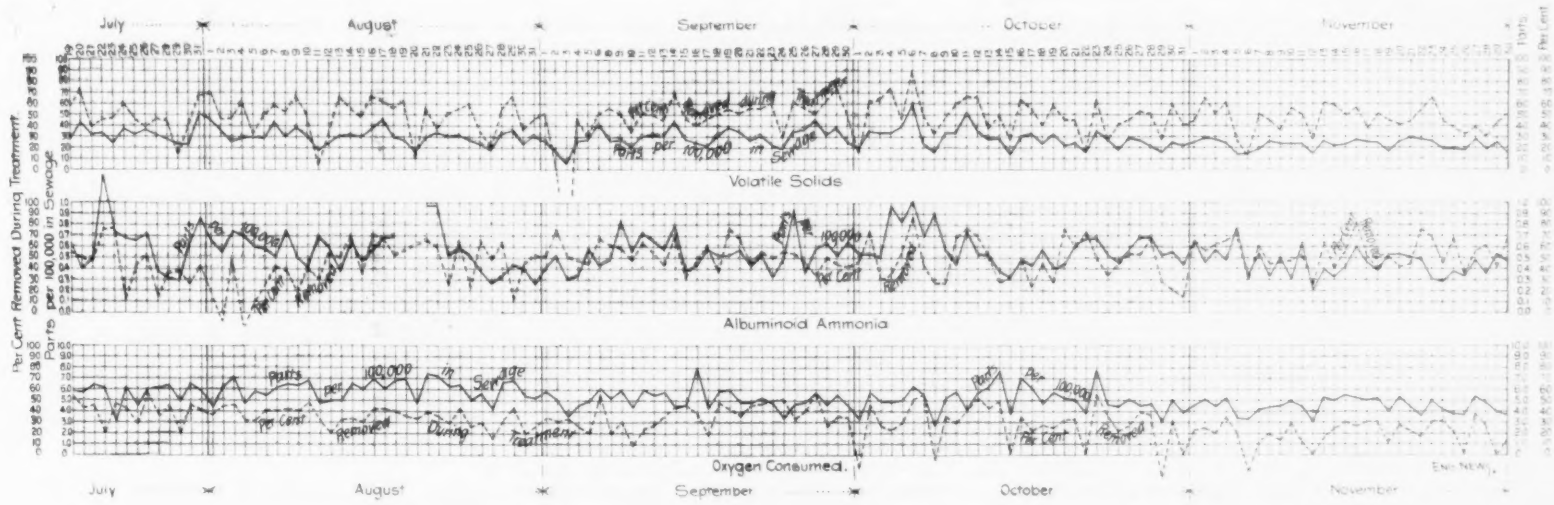


FIG. 100. DAILY CHEMICAL RESULTS AT WORCESTER FROM JULY 19 TO NOV. 30, 1893, INCLUSIVE.

In the report of the Massachusetts Board of Health for 1892 it is stated that the percentage of sewage treated at Worcester no more than offsets the increase in population, while, to quote from the report:

If we take into account that the total length of sewers in Worcester has increased much faster than the population, and that all the organic matter is not removed from the sewage by the process of precipitation, there can be no doubt that the amount of organic matter discharged into the river from Worcester is greater at the present time than it was in 1886.

Coming now to the results obtained since the enlarged works were put in operation, July 15, 1893, and all the sewage treated, we are enabled,

through the courtesy of Mr. Harrison P. Eddy, Superintendent of the Worcester sewers, to present two diagrams and a table showing the degree of purification attained and in addition a table of analyses of Blackstone River water above and below the works, giving results before and after the enlarged works were put in operation. Fig. 100 shows graphically the chemical results of each day's operation and Fig. 101 the weekly results. Table IV. presents the average results by months and for the whole period from July 19 to Nov. 30, inclusive. Table V. shows the analyses of river water, mentioned above. The diagrams show great diversity in percentages removed, which may be accounted for in various ways, chiefly by possible variations in use of chemicals and manipulation and by the fact that in the daily diagram, Fig. 100, the sewage and effluent may not have been always strictly comparable, owing to the difficulties involved in securing samples that correspond and to the fact that the samples were always the same in amount. We are informed that a change in this particular has been or is to be made so that the samples will be proportioned to the flow.

given for the whole period. The diagram, Fig. 100, since July 15, 1893.

gives a graphic illustration of analyses made daily

As the total volatile residue, the total albuminoid ammonia, and the total oxygen consumed represent the amount of organic matter, these only are shown in the diagram. The averages for the period were as follows:

	Per cent. removed.
Total volatile residue	50.88
Total albuminoid ammonia	48.49
Total oxygen consumed	33.65

The work done, as shown by these results, is very good, and should fully carry out the object of the plant, viz.: Not to transform sewage into potable water,

TABLE IV.—Averages by Months of Analyses of Sewage and Effluent from the Worcester Sewage Purification Works, for the Period Extending from July 19 to Nov. 30, 1893, Inclusive.*
(Parts per 100,000.)

	Residue on evaporation.									Ammonia.				Oxygen consumed.		
	Total residue.			Volatile residue.			Fixed residue.				Albuminoid.					
Average for periods from:	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended.	Unfiltered.	Filtered.	Chlorine.
July 19 to 31, Sewage	70.2	48.0	22.2	32.1	17.9	14.2	38.1	30.1	8.0	1.043	.622	.403	.219	5.62	3.18	6.64
Effluent	59.2	56.0	3.2	16 0	13.5	2 5	43.2	42.5	0.7	.973	.356	.239	.117	3.29	2.56	6.44
Parts removed,	11.0	—8.0	19.0	16.1	4.4	11.7	— 5.1	—12.4	7.3	.070	.266	.164	.102	2.34	.62	.20
Per cent. removed.	15.67	—16.67	85.59	50.16	24.59	82.39	13.39	—41.20	91.23	6.71	42.78	40.69	46.58	41.47	19.50	2.99
August, 1893, Sewage	61.2	40 9	20.3	30.7	18.6	12.1	30.5	22.3	8.2	1.137	.558	.258	.300	5.90	3.24	6.49
Effluent	53.9	50.7	3.2	14.9	13.5	1.4	39 0	37.2	1.8	1.083	.333	.264	.069	3 70	3.42	6.49
Parts removed	7.3	—9.8	17.1	15.8	5.1	10.7	—8 5	—14.9	6.4	.054	.225	—.06	.231	2.20	—.18	0.00
Per cent. removed.	11.92	—19.33	84.24	51.47	27.42	84.43	27.87	66.82	78.05	4.75	40.33	—2.32	77.00	37.28	—5.56	0.00
Sept., 1893, Sewage	62.1	43.4	18.7	29.3	17.0	12.3	32.8	26.4	6.4	1.488	.522	2.47	.275	5.11	3.15	6.16
Effluent	54.0	51.7	2.3	14.6	13.5	1.1	39.4	38.2	1.2	1.426	.250	.204	.046	3.33	3.03	6.01
Parts removed	8.1	—8.3	16.4	14.7	3.5	11.2	—6.6	—11.8	5 2	.062	.272	.043	.229	1.78	.12	.15
Per cent. removed.	13.04	—19.13	87.70	50.17	20 59	91.05	—20.12	—44.70	81.25	4.17	52.11	17.42	83 28	34.83	3.81	2.43
October, 1893, Sewage	67.7	46 4	21 3	28.7	16.6	12.1	39.0	29.8	9.2	1.584	.576	.279	.297	4.96	2.69	5.57
Effluent	54.0	51.6	2.4	13.3	12.5	0.8	40.7	39.1	1.6	1.504	.288	.214	.074	3.37	3.13	6.31
Parts removed	13.7	—5.2	18.9	15.4	4.1	11 3	—1.7	—9.3	7 6	.080	.288	.065	.223	1.59	— 44	—.74
Per cent. removed.	20.21	—11.20	88.74	53.65	24.70	93.40	—4.36	—31.21	82.60	5.05	50.00	33.30	75.08	32.06	—16.36	—13.30
Nov., 1893, Sewage	57.5	41.7	15.8	22.8	13.1	9.7	34.6	28.6	6.0	1.548	.450	.220	.230	4.49	2.14	5.69
Effluent	51.4	50.0	1.4	12.1	11.5	0.6	39.3	38.5	0.8	1.465	.196	.155	.041	3.49	3.30	5.57
Parts removed.	6.1	—8.3	14.4	10.7	1.6	9.1	—4.7	—9.9	5 2	.083	.254	.065	.189	1.00	—1.16	— 28
Per cent. removed.	10.69	—19.91	91.11	46.93	12.21	93.80	—13.58	—34.61	86.67	5.36	56.44	29.54	82.19	22.27	—54.20	—4.92
July 19 to Nov. 30, Sewage	62.8	43.5	19.3	28.3	16.5	11.8	34.5	27.0	7.5	1.395	.536	.266	.270	5.17	2.85	6.05
Effluent	53.9	51 5	2.4	13.9	12.8	1.1	40 0	38.7	1.3	1.325	.276	.213	.063	3 43	3 15	6.23
Paris removed.	8.9	—8.0	16.9	14.4	3.7	10.7	—5.5	—11.7	6.2	.070	.260	.053	.207	1.74	—.30	—.18
Per cent. removed.	14.18	—18.40	87.56	50.88	22.43	90.67	15.94	43.33	82.65	5.01	48.49	19.88	76.67	33 65	—10.53	—2 98

* Each day's analysis based on a sample made up of 24 equal portions, taken hourly.

but to abate and finally terminate a nuisance to neighboring villages along the Blackstone River.

Table V. shows the condition of the Blackstone River above and below the purification works. The object of these analyses is to find out exactly what is taking place in the river; whether it is being benefited by the treatment of the sewage. These analyses would appear to indicate that the work of complete purification left the river in worse condition than when only 3,000,000 gallons were treated daily. This, however, would be contrary to reason, when the 2,360 tons of

and the annual freshets which carry along these sludge deposits. When the river is full of the heavy sewage precipitate and has expended its power of dissolving impurity upon the crude sewage, there is little chance for the mud in the bed and on the banks of the stream to be carried along or dissolved; the heavy settling precipitate tends rather to hold down what is already there. On the other hand, after the sewage has been treated, there is scarcely anything in suspension, so that there is no tendency toward settlement and nothing to prevent the lighter particles of mud stirred up by the passing current from rising and being carried along downstream. Further, the river water, which before had taken into solution the raw sewage matter, is now free to act on the deposit along the banks and on the bottom of the river.

This purification of the stream is constantly going on and this solution of impurity and the rise of the lighter sludge particles from the bottom account for the apparently unsatisfactory condition of the river as shown by the analyses. This action is of very great benefit as through it and by the help of the annual spring freshets, the river is being cleaned out and until it is so cleaned the neighboring towns will not be free

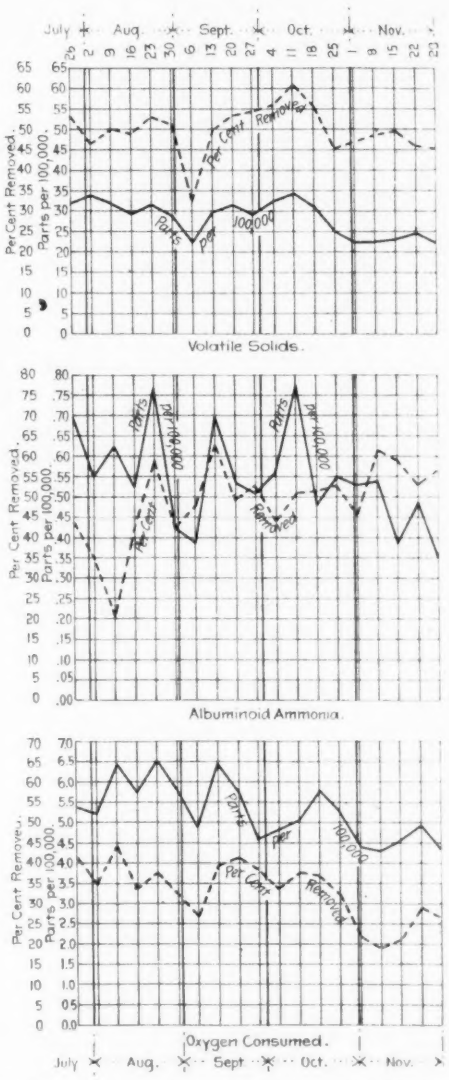


Fig. 101. Average Weekly Chemical Results at Worcester from July 19 to Nov 30, 1893

TABLE V.—Average Analyses of Water of Blackstone River Above and Below Worcester Sewage Purification Works Made During 1893.*
(Parts per 100,000.)

		Residue on evaporation.						Ammonia.				Oxygen consumed.			
		Total residue.			Volatile residue.			Albuminoid.							
Sample collected at:	Average for period from:	Total.	Dissolved.	Suspended.	Total.	Dissolved.	Suspended.	Free.	Total.	Dissolved.	Suspended	Unfiltered	Filtered.	Chlorine.	Remarks.
Washburn & Moen's Pond	Feb. 3 to July 13	7.3	6 0	1.3	2.8	2.4	0.4	.058	.059	.030	.009	.83	.65	.88	One mile above works.
" " "	July 20 " Dec. 1	9.7	8 4	1.3	5.1	4.1	1.0	.075	.052	.037	.015	1.21	.98	1.13	
" " "	Feb. 3 " Dec. 1	8.5	7.2	1.3	4 0	3 3	0.7	.067	.047	.034	.0 3	1.03	.83	1.01	
Temporary Bridge	Feb. 3 " July 13	20.3	17.5	2.8	8.0	6.8	1.2	.242	.122	.092	.030	1.60	1.15	2.31	900 ft. above works.
" "	July 20 " Dec. 1	23.2	20.6	2.6	9.8	9.0	0.8	.166	.085	.058	.027	1.40	1.11	1.38	
" "	Feb. 3 " Dec. 1	21.9	19.2	2.7	9.0	8.0	1.0	.202	.103	.074	.029	1.51	1.13	1.82	
Blackstone River	Feb. 3 " July 13	21.7	18.7	3 0	7.9	6.4	1.5	.292	.156	.107	.049	1.74	1.32	2.43	1,500 ft. below works.
" "	July 20 " Dec. 1	40.7	35.0	5.7	14.2	12.1	2.1	.706	.377	.273	.104	2 41	1 95	3.66	
" "	Feb. 3 " Dec. 1	32.3	27.8	4.5	11.4	9.6	1.8	.528	.282	.202	.080	2.12	1.68	3.13	
Morse Pond†	Feb. 3 " July 13	18.9	16.3	2.6	6.0	4.8	1.2	.261	126	.095	.031	1.50	1.06	2.46	Three miles below works.
" "	July 20 " Dec. 1	27.8	25 8	2.0	8.6	7.7	0.9	.643	.211	.158	.053	1.37	1.20	2.80	
" "	Feb. 3 " Dec. 1	24.0	21.7	2.3	7.5	6.4	1.1	.480	.175	.131	.044	1.43	1 14	2.65	
Aldrich Pond†	Feb. 3 " July 13	15.4	13.4	2.0	5.3	4.6	0.7	.237	.086	.066	.020	0.96	0.63	2.24	Five miles below works.
" "	July 20 " Dec. 1	24.9	23.3	1.6	7.2	6.5	0.7	.610	.172	.137	.035	1.18	1.06	3.45	
" "	Feb. 3 " Dec. 1	20 9	19.0	1.9	6.4	5 7	0.7	.450	.135	.107	.028	1 09	0.88	2.93	

* These analyses were made from single samples taken once every week. † Taken from outlets of ponds.

The comment of Mr. Eddy in the tables and diagrams, and some interesting remarks regarding the condition of the river, as given in his report for the year ending Nov. 30, 1893, is as follows, the table and diagram numbers having been changed:

It will be noticed from Table IV. that the sewage dealt with is remarkably strong, considering that about half of it is water coming directly from North Pond. It is also interesting to note that the effluent contains only 2½ parts per 100,000 of matter in suspension, and that of this only 1.1 parts are organic matter. Thus, by treatment, the organic, suspended matter has been removed to the extent of 90.76%. The total dissolved residue and the total and dissolved fixed residue are negative results, undoubtedly due to the large quantity of lime retained in solution in the effluent. From Table IV. the result of the treatment of the sewage since July 15 can be followed by months, and the averages are impurity removed in form of sludge is considered. How, then, can the increased amount of organic matter since July 15 be accounted for? A partial explanation is found in the fact that the water in the river was lower than it was before that date, consequently the proportion of impurity was greater. In order, however, to fully understand this condition it is necessary to interpret what is going on in the river. When crude sewage was turned directly into the river it was heavily laden with organic and inorganic matter, both in solution and in suspension. The water of the stream at once began to dissolve what it could of this suspended matter and what was still left undissolved formed a heavy precipitate, which gradually settled to the bottom, forming layers of sewage mud. This matter was continually decomposing and giving off large volumes of gas into the surrounding atmosphere. This gas is largely the cause of objection to sewage-laden streams and is only held back by the check on decomposition imposed by winter weather from disagreeable odors. Thus, while figures would appear to be discouraging, really the work done should be exceedingly satisfactory. How long it will be before the river bed is sufficiently purified so that comparatively little odor will arise from its banks is a matter of conjecture only, but, by present indications, it would appear to be a matter of a very few years. It is very necessary, however, that all the sewage should be thoroughly treated, that the accumulations may diminish, rather than increase.

Just below the results during the special study in July, 1891, are compared with those in Table IV., the percentages of total loss or ignition, albuminoid ammonia and oxygen consumed being taken for the purpose. For 1893 the average for the last 13 days in July and for the whole period from July 19 to Nov. 30 are taken. The percentages of reduction are as follows:

	Week ending July 29, 1891.	July 19 to 31, 1893.	July 19 to Nov. 30, 1893
Loss on ignition	56	50	51
Albuminoid ammonia	56	43	48
Oxygen consumed	78	41	34

The amount of chemicals per million gallons used during the special study of 1891 was given above and was much higher than the average for the fiscal year 1891. The chemicals used during the periods in 1893 named just above are not given. For the whole fiscal year 1893 a little more lime was used than in 1891, but no sulphate of alumina. From the above percentages it appears that of the total organic matter not quite half has been removed since the new works were put in operation. If we turn to the suspended organic matter, which by deposition and subsequent putrefaction has given so much trouble along the river below Worcester, the results are much better, as will be seen by referring to suspended volatile residue and suspended albuminoid ammonia, in Table IV. Of all the suspended matter in the sewage 87.56% was removed during the whole period covered by Table IV., or from July 19 to Nov. 30.

In our issue of Feb. 1, 1894, some results with chemical precipitation at Chautauqua, N. Y., were given, showing a reduction of 84% of loss on ignition and 77% of albuminoid ammonia, but only 80% of all matter in suspension. The Chautauqua figures are hardly comparable with those at Worcester, since the Chautauqua analyses were of a single sample of sewage much stronger than the average of the Worcester samples and about twice as much lime was being used at Chautauqua when the sample was taken than the average for the fiscal year at Worcester, 15 against 8.6 grains per million gallons, and in addition 2½ grains of sulphate of alumina and ¼ grain of copperas were used. Moreover, since the enlarged works were put in operation at Worcester the daily amount of sewage treated has probably been nearly, if not quite, 100 times that at Chautauqua. The latter plant is operated only during the summer season and the average results obtained during its first year, 1893, are unknown, but in 1894 there is promise that careful studies will be made.

The Worcester plant is now by far the largest sewage purification plant in this country and is well equipped in every way, excepting for sludge disposal. Fortunately, its management is in such hands, its operation so scientifically conducted and its results so carefully ascertained and recorded that it may be confidently expected to contribute largely to the fast growing body of knowledge regarding sewage purification in America.

RECENT TYPES OF STREET CAR FENDERS.

"For every evil under the sun
There is a remedy or there is none:
If there be one, try and find it;
If there be none, never mind it."

So runs the old nursery jingle, and one who views the work of inventors as recorded in the pages of the "Patent Office Gazette" must inevitably reach the conclusion that they at least have given good heed to Mother Goose's instruction. The street car fender question is an excellent example of the readiness of American inventors to seize on every new want which modern progress develops and devise means of meeting it. The past three or four years have witnessed the substitution of electric traction for animal power on the great bulk of city street car lines of the country. The patient horses jogged along at a speed of 6 to 8 miles per hour. When electric cars running at speeds of 10, 12 and even in some cases 18 or 20 miles per hour were substituted, a great increase of fatalities was inevitable; and it is these fatalities which are by the public ascribed to "the deadly trolley." Hundreds of inventors have endeavored to solve the difficult problem: How can a street car run down a person on the track without either killing him or doing him serious bodily injury? When the Massachusetts Railroad Commission experimented with fenders in 1890, nearly a score of fenders were examined or tried. In 1892, when the Commission appointed to select a fender for the West End Street Ry. undertook its work, no less than 211 fenders were submitted to it for examination. The crop has been increasing since at a great rate, and we may note as an indication of this the fact that more patents were granted for car fenders in the first six months of 1893 than in the two years 1891 and 1892.

It is fair to say, moreover, that among this multitude of devices some of those which have been recently developed appear to possess very considerable merit and to be superior to the best which were developed at the time the West End commission made its report in 1892 (Eng. News, Oct. 27, 1892).

All, or nearly all, street car fenders may be divided into two classes or types, viz.: (1) Wheel guards placed in front of the wheels or trucks and underneath the car; and (2) projecting platform fenders in front of the car.

The chief difficulty in designing a successful fender for the front of the car has been the fact that the oscillation of the car body and the unevenness of the street surface between the rails necessitate placing the fender so high above the rails to prevent it from striking the ground that it will pass over or crush down small children or persons who have fallen on the track. Especial stress was laid on this matter in the report of the special commission (Eng. News, Oct. 27, 1892) appointed by the Massachusetts Legislature to investigate the question of fenders for street cars. The fender finally recommended by that commission was a horizontal platform fender projecting in front of the car about a foot above the track, supplemented by a fender in front of the truck, operated by the motorman.

Only a very few cities having cable or electric car lines have any ordinance or regulation requiring the use of guards or fenders on the cars. The street railway companies are left free to use such forms of fender or guard as they please or none

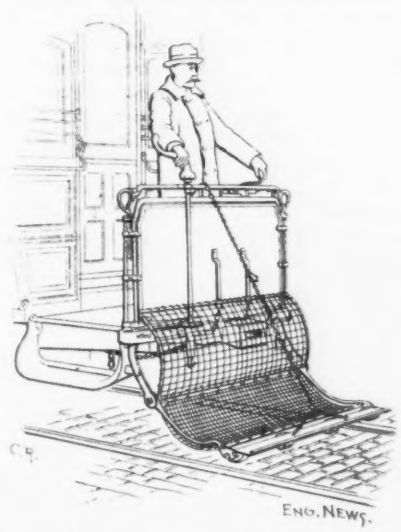


Fig. 1. The Worcester Fender, Worcester & Shrewsbury Ry. T. C. Rice, Inventor.

at all. According to the Washington "Evening Star," a circular letter sent to a large number of towns and cities by the district commissioners brought out the fact that only in a few cities was anything used as yet except a rigid wooden fender, usually a straight bar or a V-shaped frame, placed in front of the trucks, at a height of from 3 ins. to 8 ins. from the track. As is well known, these are of little practical value, since they are so high above the rails that a person's arm or leg will get underneath the wheels even if the body is prevented from doing so. Comparatively few cities appear to have had any experience with platform fenders, beyond the trial of three or four forms by some of the street railway companies.

In the accompanying sketches are shown the general appearance and construction of a number of wheel guards and fenders which have worked more or less satisfactorily in practice. These include both rigid and flexible platform fenders and a flexible wheel guard.

In Fig. 1 is shown the Worcester street car fender and guard, which is used on the Worcester & Shrewsbury Ry. This fender consists of a steel wire net cradle reaching down and forward from the ends of the sills and upward by a reversed curve to cover that portion of the car front against which a person might strike with force enough to cause serious injury. The front edge of the lower portion is a sheet metal strip 5 ins. wide covered with rubber, which also projects 3 ins. from the edge of the metal. When lowered into position for operation the edge of this rubber is from ½ in. to ¾ in. above the pavement. The upper and lower portions of the wire cradle are hinged together, as clearly shown in the cut.

To the outer edge of the fender is attached a chain which passes up over the front dasher and then down to a lever at the feet of the driver. This chain is provided with a yoke which can be released by the lever. In ordinary operation the chain holds the edge of the fender about 3 ins. above the pavement, but when danger occurs it is released by the lever at the driver's feet and the

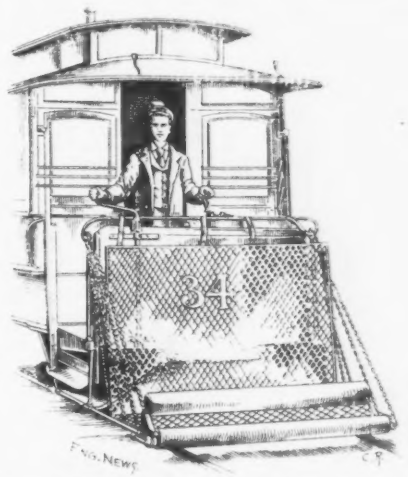


Fig. 2. The Robins Life Guard, Williamsport Passenger Ry. Co.

fender falls to its lower position, ½ in. or ¾ in. above the pavement. At this position, it may be stated, the fender rests upon four rolls which run on the pavement. When the fender is at the rear of the car the lower part is folded tight against the upper guard and occupies but little space.

As stated before, this fender is used upon the Worcester & Shrewsbury Ry., so far as we can learn, with success. In experiments made on the Foster St. Electric Ry., of Worcester, Mass., with the cars at high speeds, this fender is stated to have picked up two dummies, one 5 ft. long and the other 2 ft. long, over 60 times without tearing the clothing. The manufacturers are T. C. Rice & Co., of Worcester, Mass.

Fig. 2 shows another platform fender manufactured by the Robins Life Guard & Mfg. Co., of Philadelphia, Pa., and known as the Robins life guard. This fender consists of an iron frame bolted to the under part of the car body and extending in front of the car 3 ft. 6 ins. The frame is made of gas pipe, hinged so that it can be folded up against the dashboard, occupying a space of only 10 ins. To the frame a wire netting extending up in front of the dashboard is attached by springs. This netting is 6 ins. above the track. Across the

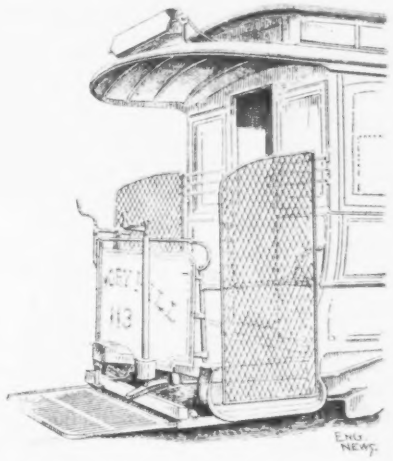


Fig. 3. The Pfingst Fender, West End St. Ry.

front end of the fender there is an elastic steel frame covered with a rubber tube 5 ins. in diameter, which is attached to the fender frame by two short springs, making a very elastic buffer. A second rubber tube is attached to the bottom netting 8 ins. from the front end of the fender. This second tube has a spring-controlled, rearward movement and is intended simply as a guard to pre-

vent a person from falling out of the fender, after having been caught up. The side chains also aid in preventing the person from falling out sidewise. The chief advantages claimed for this guard are that it strikes a cushioned blow, absolutely prevents the person from falling out and is easily attached and occupies little space when folded. It is stated that extensive experiments have been made, both with dummies and living persons and the fender has always picked them up and carried them along safely.

The Pfingst fender, shown in Fig. 3, has been adopted by the West End Street Ry. Co., of Boston, Mass., and the Brooklyn City R. R., of Brooklyn, N. Y., and is practically the form of fender recommended by the Massachusetts commission, before noted. This fender is in the form of a table or platform of wrought iron, with a floor of latticed strips, which is mounted under the car so that it may be extended parallel to the plane of the track in front of the car, or pushed back underneath the car floor when not in use. The height of this fender above the track and its rigidity would seem to be its chief objection; and unless a good wheel guard is used in addition, there would be danger to persons falling on the track of being rolled under the fender and wheels. In its construction and application to the car the fender is commendably simple.

Fig. 4. The Euphrat Fender, Broadway Cable Ry.

The fender shown in Fig. 4 is being experimented with on the Broadway cable cars in New York city, and is known as the Euphrat fender. It is constructed in two styles. As tried on the Broadway line the fender is left down all the time, clearing the ground by about 3 ins. When an object strikes the fender it springs down and almost touches the ground, the weight being carried on little wheels. The other style is of the same form, the only difference being that it is held up close under the platform, and released by the motorman pressing a treadle or by a person striking the lower edge of the dashboard. The frame of the fender is of spring steel and the netting of wire.

The Crawford patent automatic wheel guard, as shown in Fig. 5, has been adopted by the Pittsburg & Duquesne Traction Co. on its cable and electric lines and is a good example of the flexible wheel guard. As will be seen the toe plank is capable of upward, rearward and swinging backward movements, allowing it to ride over any ordinary immovable obstruction while a movable body will be pushed along in front of it by the stiffness of the springs. The toe plank can run very close to the ground. This guard can be used alone or in conjunction with a platform fender, two forms of which are manufactured by the R. A. Crawford Mfg. Co., of Pittsburg, Pa.

The fender shown in Figs. 6 and 7 is a recent invention of Mr. Samuel A. Darrach, of Newark, N. J. It was publicly tested on a car of the Consolidated Traction Co., at Roseville, N. J., on Feb. 16 and Feb. 23 on live "victims," and is said to have worked with remarkable perfection. As seen by the cuts, the fender consists of a cradle of light steel springs suspended from a gas pipe cross-bar hinged to the front of the car. When the car strikes a man standing he is tripped up and falls into the cradle. In case of a man falling on the track, however, or a child sitting there, the front fender will ride over them and in doing so the scoop frame attached to the truck is dropped automatically to the rail and scoops up the victim uninjured. The front edge of the fender attached to the car body is padded, and wooden wheels below it ride easily over an obstruction or prevent the fender from catching when the car body oscillates severely. The total weight of the fender is said to be but 35 lbs.

The six fenders illustrated cover practically all of the different types which appear to have most promise of success. They may be roughly divided into: (1) A rigid platform fender projecting horizontally in front of the car at a height of from 8 ins. to 1 ft. above the tracks and supplemented by a wheel guard operated by the motorman or one running close to the ground, as the Crawford guard (Fig. 5); (2) a flexible scoop fender operated by the motorman, like the Worcester fender (Fig. 1); (3) a flexible scoop fender running 2 or 3 ins. above the tracks like the Robbins (Fig. 2), or one form of the Euphrat (Fig. 4); (4) a simple flexible wheel guard like the Crawford (Fig. 5); and (5) a combined flexible scoop and automatic wheel guard like the Darrach.

Certainly enough has been learned from examination and test of these various fenders to make it pretty clear that one would stand much better chance of saving life or limb when run into by a car if it were equipped with any one of these various devices. At the same time it is to be remembered that no form of fender has been, or can be, devised which will do more than mitigate the risk of injury when a person is struck by a car running at the ordinary full speed of electric cars. It is to be hoped that the equipment of cars with improved fenders may go forward with all speed. At the same time it is to be hoped that the present great interest in fenders may not cause railway managers to lose sight of the fact that safety can also be greatly promoted by the use of improved brakes, which will stop the car before collision occurs.

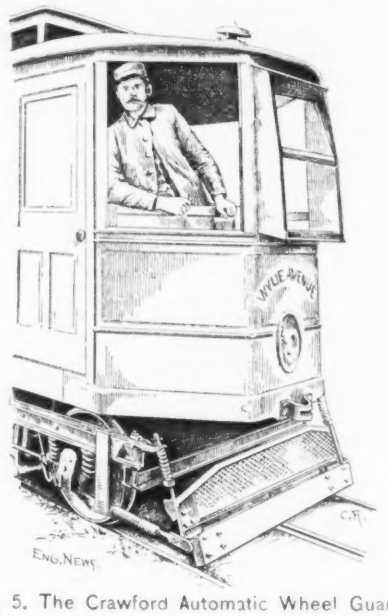
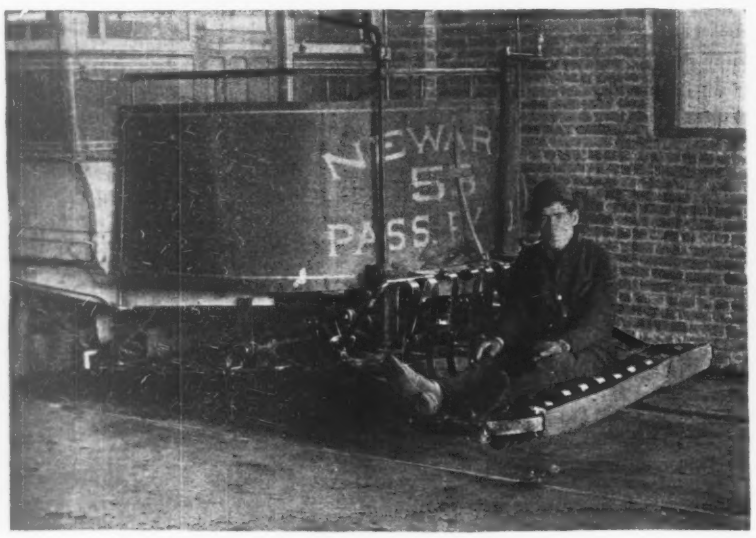
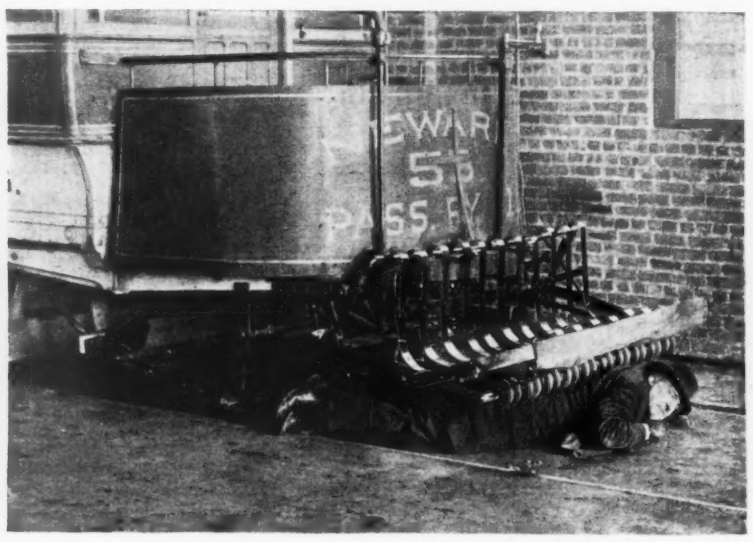


Fig. 5. The Crawford Automatic Wheel Guard, Pittsburg & Duquesne Traction Co.



"Didn't See the Car Coming."



"Striking a Man When He's Down."

FIG. 6. THE DARRACH FENDER, CONSOLIDATED TRACTION CO., NEWARK, N. J.

TEST OF A DREDGE FOR THE MISSISSIPPI RIVER COMMISSION.

A powerful self-propelling suction dredge has recently been built for the Mississippi River Commission (Fourth District) and a test of its efficiency was made on Jan. 29. The contract requirements were in part as follows:

> Practical capacity to be not less than 300 cu. yds. of solid matter per hour, when discharging over a bar or bank not less than 10 ft. above water surface, and with the point of discharge not less than 300 ft. distant. The dredge must be capable of working effectively in stiff clay and sand, and must be capable of cutting its own way through a solid bank above water. It must be able to work in all depths down to 30 ft., and to discharge the material on either side, to a distance of 1,000 ft., and over a bank 35 ft. high above bottom of cut. It must admit of easy and rapid handling in a narrow channel in shoal water and in a rapid current.

The dredge was built on the Ohio River and proceeded to its destination in Louisiana under its own steam, making a speed of seven miles per

hour, towing 11 pontoons. The test for capacity took place on Jan. 29, under supervision of Capt. John Millis, representing the government, and Mr. A. W. Robinson, M. Am. Soc. C. E., representing the builders. The volume of discharge was measured by diverting the stream into watertight bins upon a large flat scow, fitted with suitable sluices and gates. Samples of the discharge were taken in this way for periods of 30 seconds every half hour during the test. At the conclusion of the test the contents of the bins were allowed to settle undisturbed for 40 hours, and the contents were accurately measured. The water was then drawn off and the residue measured. This residue was found to consist of semi-fluid mud on top and solid material in the bottom, and was therefore measured separately, with results as follows:

Duration of measured trial	3	hours
Total time pumping into scow	3	minutes
Total measured volume	70.76	cu. yds.
Volume of residue after settling 40 hours	38.37	cu. yds.
Percentage, residue total volume	54	%
Rate of discharge of residue per hour	777	cu. yds.
Volume of semi-fluid mud drawn off after 40 hrs.	16.37	cu. yds.
Volume of solid matter left	22	cu. yds.
Semi-fluid mud reduced to solid material	9.82	cu. yds.
Total solid material discharged in 3 mins.	31.82	cu. yds.
Percentage of above to total volume	45	%
Rate of discharge of solid material per hour	636.4	cu. yds.

The dredge was making a cut 100 ft. wide and 14 ft. deep, discharging 10 ft. 6 ins. above the water at the prescribed distance, and the result, shown above, was more than double the guarantee. We are informed that this large output was obtained steadily, and that no attempt was made to sort the material. The material is excavated and fed uniformly and continuously to the pump by a rotary steel cutter head of improved form, so that the pump and pipe is always worked up to its maximum carrying capacity, and the percentage of solid matter is under perfect control. The dredge was built by the Bucyrus Steam Shovel & Dredge Co., of South Milwaukee, Wis., from the designs of Mr. A. W. Robinson, M. Am. Soc. C. E., the company's Chief Engineer.

STEAM DISTRIBUTION FOR HIGH-SPEED LOCOMOTIVES.*

By C. H. Quereau, M. Am. Soc. M. E., Engineer of Tests, C., B. & Q. R. R.

The modern practice and tendency in railway operation is to haul the greatest amount of paying load with the least outlay for motive power, and, for this reason, the weight and hauling capacity of locomotives have been increased in the past few years to such proportions that many thoughtful men consider it doubtful whether their size and number of parts can be still further increased with economy. When we consider what a farther increase in weight, dimension, number of parts, and hauling power of the latest designs of locomotives, and the consequent increase in the length of trains means in the way of increased expenditures on tracks, bridges, yards, sidings, roundhouses, turntables, and in numerous other directions, and the increased difficulties attending a farther increase in the length of our present trains, it is apparent that the doubters have good ground for argument, the force of which is more especially felt in those sections where land and taxes are high, and will be more and more convincing as the country becomes more thickly settled and values rise. So far, the means used to lessen the cost for motive power has, generally, been an increase in the weight of locomotives. A little consideration will show that an increase in speed will accomplish the result sought, viz., reduce the number of engines necessary to handle the traffic. There is a growing conviction in Europe that the economical length of train has been reached, and there is, therefore, a movement toward increasing the speed. In this country the Empire State Express, Pennsylvania Limited, Exposition Flyer and a number of limited trains, show that there is a market for high speeds.

The object of this paper is to direct attention to the subject of the proper distribution of steam for high speeds; not to any special design or type of locomotive or valve gear, but to important facts which should be kept in mind in designing or altering valve gear for high speeds. Unless the contrary is expressly stated, all cards used were taken when the throttle was wide open, and from C., B. & Q. engines with the same apparatus and by the same operator.

A brief discussion of the compound locomotive is appended, but the paper proper is confined to the consideration of single expansion locomotives.

Boilers.—High speeds demand a greater steaming capacity than slow speeds. More trouble is experienced in making high-speed engines steam properly, and, therefore, more heating surface and larger boilers are required. If a certain amount of steam is required to make an average speed of 30 miles an hour, and assuming for the present that it requires no greater tractive force to keep a train moving 60 miles an hour than 30, it is evident that the engine moving at the rate of 60 miles per hour uses just twice as much steam in a given time as it would if going at 30 miles. It is therefore certain that the boiler of the faster engine must supply steam at least twice as rapidly as that of the slower one. If we further consider that it requires a greater tractive force to maintain the higher speed, it is plain that the high-speed engine will use more than twice the amount of steam necessary for the slower engine. Hence the necessity for large boilers and heating surface for high-speed locomotives.

Balanced Valves.—The importance of having slide valves properly balanced is generally understood in the United States. Mr. Philip Wallis, in 1886, when Engineer of Tests for the C., B. & Q. R. R., reported that while 6 HP. was required to work unbalanced valves at 40 miles per hour for the balanced valves 2.2 HP. only was necessary.

Effect of Speed on Average Cylinder Pressure.—Assume that a locomotive has a train in motion, the reverse lever is placed in the running notch, and the track is level, by what is the maximum speed limited? The resistance of the train and the load increase, and the power of the locomotive decreases with increasing speed till the resistance and power are equal, when the speed becomes uniform. The power of the engine depends on the average pressure in the cylinders. Even though the cut-off and boiler pressure remain the same, this pressure decreases as the speed increases; because of the higher piston speed and more rapid valve travel the steam has a shorter time in which to enter the cylinders at the higher speed. The following table, prepared from indicator cards taken from a locomotive at varying speeds, shows the decrease of average pressure with increasing speed:

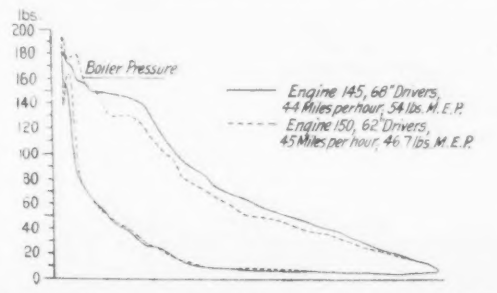


Fig 1. Effect of Large Drivers in Increasing Mean Effective Pressure.

Card No.	Miles per Hr	Speed rev.	Av. press. per sq. in.—Actual.	Av. press. per sq. in.—Calculated.
17	46	224	51.5	....
18	51	248	44.0	46.5
21	51	248	47.3	46.5
19	53	258	43.0	44.7
20	54	263	41.3	43.8
23	57	277	42.5	41.6
22	60	292	37.3	39.5
24	66	321	36.3	35.9

The column "average pressure calculated" was figured on the assumption that the mean effective pressure would decrease in the same ratio that the speed increased. The actual and calculated pressures agree closely, showing that the average pressure decreases in proportion as the speed increases, at least at speeds above 40 miles an hour. The main difference lies in the higher steam line at the lower speeds, and consequent higher expansion line, showing that more steam entered the cylinder. The back pressure and compression lines agree quite closely for all the cards, though they are slightly better for the slower speeds. That the difference is not greater may safely be attributed to the large exhaust ports, passages and exhaust tip, which is 5 ins. diameter. These are matters of great importance for high speeds.

Boiler Pressure.—The increase of train resistance with increased speed is not as the square of the velocity as is commonly supposed. It is more likely that it increases as the speed after about 20 miles an hour is reached. Assuming that the latter is true, and that an average of 70 lbs. per sq. in. is the greatest that can be realized in the cylinders of a given engine at 40 miles an hour, and that this pressure furnishes just sufficient power to keep the train at this speed, it follows that, to increase the speed to 50 miles, the mean effective pressure must be increased in the same proportion, or to 62.5. In short, to increase the capacity for speed of any locomotive its power must be increased, and at least by as much as the speed is to be increased. One way to accomplish this is to increase the boiler pressure. That this is generally realized is shown by the increase in boiler pressure in the last ten years. For 23 single expansion locomotives described in the railway journals this year, including those of the Columbian Exposition, the steam pressures are as follows: 3, 160 lbs.; 4, 165 lbs.; 2, 170 lbs.; 13, 180 lbs.; 1, 190 lbs.

The Size of Driving Wheels.—The following table is made up from the data found in Wm. Forsyth's paper "Tests of Locomotives in Heavy Express Service," presented at the February meeting of the Western Railway Club, 1893, and Fig. 1 shows two indicator cards showing the effect of larger drivers on the steam line:

Engine.	Dia. drivers over all.	Av. water per dyn. HP. per hour.	Av. steam. press.
No. 145	68 ins.	32.90 lbs.	159.9 lbs.
No. 150	62 ins.	35.15 lbs.	157.3 lbs.

Except the diameter of the drivers the engines were as near alike in design, boiler pressure, average speed and the valve gear, as they could be made, and were tested to determine the influence of the drivers on their economy in fast passenger service. The trains hauled consisted of ten cars, weighed about 350 tons, exclusive of engine and tender, which weighed 82 tons, and the speed was 42.8 miles an hour, exclusive of stops. During a trip engine 150, because of her smaller drivers, made 8.8% more revolutions than engine 145, and, as shown by the above table, used 7% more steam. Or reversing the statement, the steam economy of engine 145 was about proportional to her economy in revolutions, or, the steam consumption was inversely proportional to the diameter of her drivers. Engine 145 was able to do the work required at cut-offs from 4 ins. to 6 ins., probably the most economical range for locomotives. Engine 150, because of her smaller drivers, could furnish the same power at somewhat shorter cut-offs, but the necessarily higher piston speed produced uneconomical wire drawing and compression. I think the broad statement may safely be made that, as far as the distribution of steam for high speeds is concerned, the economy will increase with increasing diameters of drivers, provided the work at average speed does not necessitate a cut-off longer than one-fourth stroke. The reason for this is evident when we consider that the larger the drivers the less the speed of the pistons and valves; the slower the piston and valve speed, the greater the average cylinder pressure and the more economical the steam distribution. The piston speed of a locomotive with 62-in. drivers, at 55 miles per hour, is the same as that of one with 68-in. drivers at 61 miles per hour. Not only does the use of large drivers secure a more economical use of steam and permit higher speeds, but I am decidedly of the opinion that they will lessen engine, track and bridge repairs.* The use of higher steam pressure will allow the use of larger drivers.

Allen Valves.—There is considerable difference of opinion as to the advantage of the Allen ported valves (Eng. News, July 6, 1893). The Superintendent of Motive Power of one of the best known Eastern trunk lines says he is "unable to find any particular merit in the Allen valve, and use of this feature increases the weight to such an extent that we did not think it advisable to use it." On the other hand, Mr. Von Borries, of the Hanover State Railway, writes: "The Allen valves are most useful for all fast-running engines. Our people could not do without them." The object of the Allen port is to provide a larger area through which steam may enter the cylinder, securing either a higher average cylinder pressure, hence more power at a given cut-off, or permitting the use of a shorter cut-off and greater expansion in doing the same work as a plain valve, thus using the steam more economically. Its advocates, however, overlook the fact that the steam is considerably wiredrawn by passing through two small passages, one at each end of the valve, and its opponents likewise magnify the importance of the greater weight of the valve due to the Allen port, and do not sufficiently realize the advantages of the higher cylinder pressure obtained. Judging by results given in Mr. Wm. Forsyth's report of "Tests of Locomotives in Heavy Express Service," in the printed proceedings of the club for February, 1893, I should say that a valve with an Allen port ½ in. x 17¼-in. and 5-in. travel was about as efficient as a plain valve with 6-in. travel. It should not be forgotten that the Allen port enlarges the steam opening by the same number of inches for all points of cut-off, while a longer valve travel enlarges it a certain per cent., the number of extra square inches decreasing as the cut-off grows shorter. The Allen port always leaves its distinguishing marks on cards from single expansion locomotives. The wavy compression line is its sign manual.

Valve Travel.—An increased average cylinder pressure may also be obtained by increasing the valve travel without raising the boiler pressure, and better results will be obtained by increasing both. If the valve travel is increased without increasing the outside lap, or the outside lap is not increased out of the proper proportion, not only is the next opening for a given cut-off increased, but the port is opened more quickly, the result being that the longer travel gives a higher steam pressure in the cylinders. Nor is this the only beneficial result. The longer travel gives a later exhaust opening, later exhaust closure and a larger exhaust opening, all necessary for high speeds and economy. It is doubtful if the mere statement of these advantages of increased travel will prove convincing, and a practical illustration worked out in actual practice will serve the purpose better. We have a number of consolidated engines for heavy grades and work which have drivers 52 ins. over all, 20-in. cylinders, small steam and exhaust

* Condensed from a paper read before the Western Railway Club at the February meeting.

* See the "Vertical Influence of the Counterbalance," Eng. News, Feb. 22, 1894.

passages and large grate area, making a small exhaust nozzle necessary, and carrying 145 lbs. steam pressure. They were designed at a time when train speeds were slower than at present, and answered their purpose, but their proportions form a combination not well fitted to keep up with the times. Their high piston speed, low boiler pressure and contracted steam passages make the average cylinder pressure quite low, while the contracted exhaust passages cause considerable back pressure and compression. Their boilers will not permit increasing the steam pressure, and it was decided to try the effect of increasing the valve travel from 5 ins. to 5½ ins. by increasing the throw of the eccentrics, as there was room in the steam chests for this increase. Though the change was slight the effect was noticeable. Fig 2 shows cards taken before and after the change. At a speed 13% greater the 5½-in. travel gave 9.5% greater power, or increased the possible speed of the engine. This gain was due solely to a slightly increased valve travel, as this was the only change made in the engine.

It was claimed that increasing the valve travel increases the mean effective pressure by giving a greater port opening both for admission and exhaust, and I think there can be no reasonable doubt that the claim is made good. When the engine had 5 ins. valve travel she was among the poorest of her class—loggy and a "coal eater." Since the travel was increased to 5½ ins. she has been much smarter, hauling the fast merchandise and stock trains on time, a thing she could not do before, and has led her class in the number of miles made per ton of coal. As she is run in a pool, and her good record has been held for about a year, it seems evident that the change may safely be attributed to the increased valve travel.

Steam Ports.—The length of steam ports ranges from 15 ins. to 23 ins., and has considerable influence on the power, speed and economy of the locomotive. In cards from similar engines not reproduced) the steam line of the card from the engine with 23-in. ports, is considerably nearer boiler pressure than that of the card from the engine with 17¼-in. ports. That the higher steam line is due to the greater length of steam port there is little room for doubt. The 23-in. port produced 531 HP. in an 18½-in. cylinder at a cost of 23.5 lbs. of indicated water per I. HP. per hour. The 17¼-in. port 424 HP., at the rate of 22.9 lbs. of water, in a 19-in. cylinder. This shows the 23-in. port generated 25% more power with but 2.6% loss in economy. The engine with 23-in. ports, however, had a 4⅝-in exhaust nozzle. Had this engine had a 5in. nozzle, like the other, its record would have stood 576 HP. and 21.6 lbs. of water per HP.

Long Valve Travel vs. Long Steam Ports.—It is not simply the fact that the ports are long which produces the above results, but the increased area through which steam may enter the cylinder. This increased area may also be gained, as already noted, by increased valve travel. If, in increasing the area for steam admission, I was limited to the use of either an increase in length of steam port or to increase the valve travel, I should choose the latter without hesitation. The reason being that a long, narrow steam opening of the same area as a shorter and wider one has more inches of edge over which the steam is wire-drawn, and is therefore much less efficient. With a valve having 7-in. travel and 1¼-in. outside lap, the port opening is about ½ in. at 6-in. cut-off. If the steam port is 17 ins. long the area of the steam opening is 8.5 sq. ins. For a 5½-in. travel and ⅞-in. outside lap, the port opening is about 5-16 in., therefore, to obtain 8.5 sq. in. steam opening, the length of the steam port for the 5½-in. travel must be 27 ins. In addition to the disadvantage of using such a long port, it should not be forgotten that the 27-in. port and 5½-in. travel make it necessary to use 54⅝ ins. of port edge over which the steam is wire-drawn, while the 17 in. port and 7-in travel give but 35 ins., making the latter much more effective. I believe that a 20-in. port and 6½-in. (or even 7-in.) travel could be successfully used for high-speed engines, and that frequently by so doing the cylinders could be economically reduced and the counterbalance lightened. Or, better still, the diameter of the drivers increased, securing lighter counterbalance and better steam distribution.

Lead.—There is a quite common impression that lead should be so adjusted as to give a cushion at the end of the stroke. This seems to me to be a mistake as far as locomotives are concerned. Compression would furnish all the cushion necessary. Indeed, one of the most common defects with locomotives, high speed or otherwise, is that there is too much compression. This is due to the valve gear and the fact that a forced draft, and hence contracted exhaust, is necessary. If to this is added lead for the purpose of cushion, the result is a hard-riding and comparatively loggy engine. I should say the proper object of lead is to secure, as nearly as may be, full boiler pressure in the clearance spaces and provide as large a port opening as possible just as, or after, the crank passes the center, not before. It is evident that if pressure is allowed in front of the piston before it reaches the end of the stroke, it will take up the lost motion in the parts and block the engine, diminishing its speed. If this pressure is caused by the compression of steam which was left in the cylinder when the exhaust closed, the pressure will increase comparatively slowly and the lost motion be taken up gradually. A certain amount is necessary for the proper working of a high-speed engine, but if the lead opens soon enough to allow a considerable pressure in the cylinder before the crank reaches the center, the lost motion will be taken up and the piston blocked suddenly, the crank-pin friction increased, and, as a consequence, the power and speed will be diminished and the engine will ride with a constant rattle and jar if the speed is high. If the speed is slow the crank-pin will pass each center with a thump.

The Stevenson link motion is almost universally used in the United States; and this type of valve gear, as usually set, gives an increasing lead as the cut-off is shortened, the increase depending mainly on the length of the eccentric blades. The shorter they are the greater the increase in lead as the engine is hooked back. The eccentric blades are usually shorter on consolidation, mogul and ten-wheel engines than on those of the eight-wheel type. Consequently, the lead on the first three increases faster than on the last, and this will account for the fact that the last generally rides with less jar than any of the others. All the passenger engines on the Pittsburg, Ft. Wayne & Chicago Ry., except those which run backward considerably, have their valves set with a small constant lead. This was done to overcome a disagreeable fore and aft motion at high speeds, which it did successfully. Such of them as have Stevenson valve gear have the lead made constant by making the lead 13-32-in. negative in back motion. On others the Allen gear is used. The lead used with these is from 1-16-in. to ⅛-in. In Germany, France and England the valve gears most generally used are those which give a constant lead for all cut-offs, as the Allen, Joy or Walschaert. The lead on German engines with these gears is from 0.12-in. to 0.16-in. for Allen valves, and from 0.16-in. to 0.2-in. for plain valves; in France it is about 0.2-in.; in England, from 0.2-in. to 0.2.5-in.

The great objection to constant lead is the fact that if adjusted to the best advantage for full gear and slow speeds, it is not sufficient for short cut-offs and high speed. If set properly for high speeds, it is too great

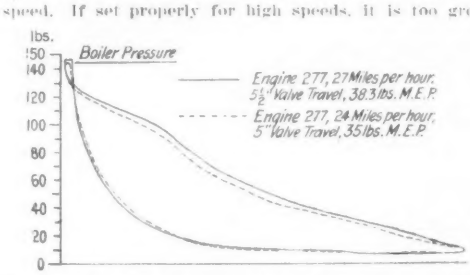


Fig. 2. Effect of increased Valve Travel in Increasing Mean Effective Pressure.

for slow speeds, the engine is not "smart" in accelerating a train, and the rods hammer as the crank-pins pass the centers. For these reasons I should say that the lead should be variable and increase as the engine is hooked up and the speed increases. Foreign engineers have chosen a constant lead adjusted to give the best results at high speed.

If 1-16-in. lead at full gear is the best for a plain valve about half that amount will answer the same purpose if the valve has an Allen port. If ⅛-in. lead will answer for a plain valve at 6-in. cut-off, ¼-in. will accomplish the same end with an Allen valve. The effect of this reduction of lead is three-fold. It changes the cut-off for a given notch in the quadrant, and delays both the point of exhaust opening and closure.

Lead Produces Compression.—Engines of a certain class on the C., B. & Q. were noticeably rough-riding and constantly "jumping" at high speeds. The cabs rattled badly, and the engines were uncomfortable to ride because of the constant jar and vibration. The cause was found to be too much lead at short cut-offs. In other words, the lead increased too rapidly as the engine was hooked up. When this was properly adjusted the engines rode smoothly and without jar except that due to the track, and made better time. From being among the worst, they are now the best riding engines on the road. Some of the enginemen claim that less coal is used than before, but this is only a matter of opinion, though calculations from the indicator cards show some saving. A number of engines of the same and one other class have had their valves set in the same way, with the uniform result of a decided improvement. Not only does a correct lead make the engine freer and more speedy when under way, but is an important item in increasing the average speed, as it will get a train up to speed with considerable more rapidity. The latter has been spoken of by all the enginemen who have tried these engines. Why the change in lead should have this effect I cannot say definitely, but that it is so is proved by experience. The economy of the engine, as figured from the indicator cards, increases slightly as the lead is reduced, and the best economy is obtained when the engine is riding smoothly.

Reducing Mid-Gear Lead.—An excellent method of reducing lead and consequent compression is by altering the position of the back-up eccentric. This, it is true, will give a slight negative lead when the engine is backing, and it has been argued that, because of this, an engine should not have her mid-gear lead reduced by moving the back-up eccentrics, as this will cripple her in backing. But except a few engines in suburban service, there is little occasion for road engines to do any work in backward motion except in switching, and that they will do this satisfactorily experience has shown. We have tried it on freight engines. The fact that the cut-off in back gear is longer than in forward gear for the same position of the reverse lever makes the engine stronger in backing up. The fact that the lead is negative has little weight, as switching is done at slow speed.

During the tests to decide the best adjustment of lead it was determined that the jar and vibration of the engine at high speed were largely, though not entirely, remedied by reducing the full gear lead to 1-64 in. all around. Bearing in mind that the mid-gear lead is reduced by practically the same amount as the full gear lead, the betterment was evidently brought about by the reduction of the mid-gear lead. The reduction of the mid-gear lead, secured by moving the back-up eccentric, makes the cut-off somewhat shorter than before for the same notch in the quadrant. For this reason, when the plan was first put in practice by us, the enginemen objected to the change because they had to work the engine with a cut-off a notch or two longer than they had been accustomed to till the train had attained running speed, and naturally thought they were using more steam. They soon found, however, that it took no more steam, and some claim they use less, and that, when the train has attained a fair speed, the engine could be hooked up to about the old notch, and gradually increase the speed till it was greater than had been reached with the old adjustment of lead. Besides, the engine rode smoothly.

A reduced mid-gear lead, secured by adjusting the back-up eccentric, is used by the P., Ft. W. & C. R. R. on such of its passenger engines as have the Stevenson valve gear; by the C., C., C. & St. L. on its class Y passenger engines; by the H. & St. J. for all its locomotives. It has been used for about a year by the C., B. & Q. for its high speed passenger engines with Allen valves with uniform success.

Throttle vs. Reverse Lever.—Foreign engineers have commented on American fondness for throttling by saying in substance that we run our locomotives with open throttles only when taking indicator cards, and those who have had opportunities for knowing must confess there is considerable truth in the criticism. Not only do master mechanics permit it, but most runners persist in it. The former probably not realizing that the practice is slovenly and wasteful, and the latter because it is so much easier to handle the throttle rather than the reverse lever. The question to be considered is not whether there are sometimes conditions that make it more economical to throttle, as when an engine with cylinders 19 × 24 ins. is hauling a three-car train at an average speed of 35 miles an hour, or whether it is more economical to run an engine at one-fourth cut-off or one-sixth, but, is it more economical to run a locomotive under average and usual conditions with long cut-off and partly opened throttle, or with wide open throttle and a correspondingly shorter cut-off. The proper subject to be discussed is expressed in the following hypothetical question: Is it more economical to operate the engines hauling the Exposition Flyer or the Empire State Express, with from 7½ ins. to 8½ ins. cut-off, and the throttle from one-half to one-eighth open, or to do the same work with a wide open throttle and cut-offs ranging from 4½ ins. to 6 ins.? Unquestionably, it is more economical to run with full throttle opening.

A card taken from engine 870 while hauling the Empire State Express at a speed of 58 miles an hour, with throttle one-eighth open, shows 445.6 HP., at a cost of 24.5 lbs. of indicated water per I. HP. per hour. A card from engine 617, at a speed of 58 miles an hour, with wide open throttle, shows 443 HP., produced at an expense of 20.1 lbs. of indicated water per I. HP. This shows a saving of 18% for 6-in. cut-off and open throttle, when compared with the results obtained with 8½-in. cut-off and throttle nearly closed. From these and other cards it is evident that the engine might have run with wide open throttle, a shorter cut-off, and have developed the same power at less expense.

It is true that it is not entirely safe to rely on a comparison of the indicated water as a measure of an engine's economy when the cards used are taken at cut-offs varying considerably, because of the different amounts of steam condensed, the condensation not being shown by the cards. Throttled steam is drier than unthrottled, and the amount condensed under the latter condition is larger than when the steam is superheated by throttling. Yet the results of careful tests have shown that throttling is uneconomical, even

when the cut-off for full throttle is as short as one-fifth of the stroke; a little less than 5 ins. for 24-in. stroke. It is strange that motive power departments will design valve gears of the most approved patterns and then permit the steam to be distributed by the throttle. When this practice is allowed, higher boiler pressure, longer valve travel, or longer steam ports, will result simply in a little closer throttling and a finer notched throttle quadrant. It is not a valid excuse that with short cut-offs the full throttle makes the engine ride hard because of the large lead, or at high speeds the reverse lever is hard to handle. Both can easily be remedied.

Inside Clearance.—There is quite a general prejudice against inside clearance, the common belief being that it wastes steam by releasing it too soon, no thought being given to the accompanying fact that compression is reduced. The loss from inside clearance at the exhaust end is insignificant when compared with the gain from inside clearance at the compression end. If I was requested to recommend the proper inside clearance for a high speed locomotive, and this discussion relates to such, I would first adjust the lead till the indicator cards showed a smooth compression line, one free from abrupt change when lead opened. I would then increase the inside clearance by not less than 1-16 in. on each end at a time, as long as the card showed a gain in area by so doing, resting assured that I was increasing the economy of the engine. The effect of 1-32-in. inside clearance is scarcely discernible at 6-in. cut-off. Inside clearance of from $\frac{1}{8}$ in. to $\frac{1}{4}$ in. on each end is not uncommon on high speed locomotives, nor do I think it excessive. The amount of inside clearance necessary depends mainly on the valve travel and the lead. The longer the travel and the smaller the lead, the less the inside clearance needed. What has already been said shows that inside clearance has but little effect on back pressure. This is almost entirely controlled by the size of the exhaust passages and tip. Because of the already great length of the paper, I have thought best to say nothing concerning outside lap.

Conclusions.—In the preceding discussions it has been assumed that economy as well as speed is desired, and that locomotives will be run with wide open throttle. If the latter is not true, the proportions of the valve gear are of minor importance. Boilers and grate areas must be larger, and heating surface greater for high than for slow speed engines of the same class. The train remaining the same, the work done in hauling the train increases no less rapidly than the speed. It is therefore evident that for the same train loads high speeds require more powerful engines than slow. Other things being equal, the average cylinder pressure, and therefore the power of the engine, decreases with increasing speed. To overcome this the following remedies may be used: Increased boiler pressure, larger drivers, Allen valves, increased valve travel, increased length of ports, proper adjustment of lead to reduce compression, sufficient inside clearance.

The preceding may be considered as theoretical, but the following, condensed from the large table accompanying, is historical and the outgrowth of experience. This table gives the principal dimensions which affect steam distribution, from the standard locomotives for through passenger service of seven trunk lines and four prominent locomotive builders, both for 1882 and 1893. None of these engines are experimental or unusual, but standards in actual service.

	1882.	1893.	Inc.
Grate area	16.95 sq. ft.	24.62 sq. ft.	45.2 %
Tot. heating surface	1,161 sq. ft.	1,616 sq. ft.	39.2 %
Diameter of boiler,	50.5 ins.	57 ins.	6.5 %
Outside diameter of drivers	64.6 ins.	71 ins.	5.4 %
Steam pressure	135 lbs.	174.5 lbs.	29.2 %
Steam ports	1.18 × 15.9	1.37 × 17.1	.....
Steam ports, area.	18.76 sq. ins.	23.43 sq. ins.	25 %

Appendix.

Compound Locomotives in Fast Passenger Service.

The following table is compiled from the results of careful tests of simple and compound locomotives in passenger engines is at high speed. Under this condition the cut-offs are comparatively short, ranging from one-fourth to one-fifth, even with trains weighing as much as 425 tons. The steam is therefore expanded in the simple engine about as much as can be done economically. It can be shown that cylinder condensation decreases as the speed increases. Therefore the amount that a compound can save because of less cylinder condensation is considerably reduced when speed is high. As far as I am able to learn, the size of the exhaust tip used with compound locomotives is seldom larger than that used on simple locomotives of the same power, and frequently the tip of the compound is somewhat smaller. This will explain the higher back-pressure of compounds when compared with simple. There is a further consideration which has a bearing on this point: a compound having cylinders 20 ins. and 29 ins. by 24 ins. is considered the equivalent of a single expansion engine having cylinders 19 × 24 ins. The area of a 19-in. piston is 283.5 sq. ins.; of a 29-in. piston, 660.5 sq. ins. So that the low-pressure cylinder of the compound has to exhaust nearly two and a half times as many cubic inches of steam as the 19-in. cylinder. At slow speeds there is time in which to do this without creating much back-pressure, but at high speeds the case is altogether dif-

CHANGES IN DESIGN OF THROUGH PASSENGER LOCOMOTIVES, 1882-1893.

Builder.	Year.	Grate area, sq. ft.	Total heating surface, sq. ft.	Boiler diam., ins.	Driver diam., ins.	Steam press. lbs.	Cylinder diam. and stroke, ins.	Kind of valve.	Lead at full gear, Valve travel, ins.	Lead at full gear, ins.	Lead.	Outside lap, ins.	Inside lap or clearance, ins.	Steam ports, ins.	Exhaust ports, ins.	Type of engine.
N. Y. Central & Hudson River R. R.	1882..	17.87	1,353	50	70	150	17 × 24	Rich. bal.	5¼	1/16	Increasing	7/8	1/8	15½ × 1¼	.....	American
	1893..	27.3	1,821	58	78 & 86	180	19 × 24	Rich. bal.	5¼	1/16	"	1	0	18 × 1¼	.....	"
Michigan Central.....	1882..	17.5	1,282	50	63	135	17 × 24	Unbal. "D"	5½	1/32	"	3/4	1/16 lap	1⅝ × 16	.....	"
	1893..	28 6	1,733.8	58	68	160	19 × 24	Bal. Allen	5½	1/16	"	7/8	1/32 lap	1⅝ × 18	.....	10-wheel
Chicago, Mil. & St. Paul	1882..	17.1-17.1	1,090-1,030	50-50	63-69	140-140	17 × 24-18 × 24	Plain bal.	5-5⅝	1/16-1/16	"	7/8-7/8	1/32 1-1/32 1	1¼ × 16-1⅝ × 17	.....	American
	1894	17-17	1,177-1,350	52-54	62-69	180-150	17 × 24-18 × 24	Plain bal.	5⅛-5½	1/16-1/16	"	¾-¾	1/32 1-1/32 1	1¾ × 17-1¾ × 17½	.....	"
Chicago, Burl. & Quincy.	1882.	18	1,190	52	69	145	18 × 24	Plain bal.	5	1/16	"	7/8	1/32 1	1¼ × 16	.....	"
	1893.	25	1,689	60	69	180	19 × 24	Allen bal.	5	1/32	"	7/8	1/16 clear	1½ × 17¼	.....	Mogul
Lake Shore & Mich. So'n	1882.	17	1,180	47	60	125	17 × 24	Plain D	5	1/8	Incr. to 11/32	7/8	0	1 × 15	.....	American
	1893.	18	1,450	52	72	180	17 × 24	Allen bal.	6	0	Incr. to 1/2	1	1/16 1	1⅝ × 16	.....	"
Chic., R. I. & Pacific.....	1882..	15	1,100	56	63¾	135	18 × 24	Plain bal.	5½	1/32	Increasing	7/8	0	1¼ × 15	.....	"
	1893..	17.6	1,481.7	56	68¾	170	18 × 24	Allen bal.	5½	0	"	1	0	1¼ × 17	.....	"
		23.6	1,898	60	68¾	170	19½ × 24	Allen bal.	5½	0	"	1	0	1¼ × 17	... ...	10-wheel
Pennsylvania R. R.....	1882	17.6	1,057	50	62	125	17 × 24	Plain D	5	1/8	"	3/4	0	1¼ × 16	.....	American
	1893.	33.25	1,583	57	78	175	18½ × 24	Bal. D	5½	0	"	1	1/8 clear	1¼ × 17¼	.....	"
Schenectady Loco. W'ks	1882..	17.12	1,145	50	68	130	18 × 24	Unbal. D	5⅜	1/8	"	7/8	1/16 1	1⅝ × 16	.....	"
	1893..	18.2	1,709	56	68	180	18 × 24	Bal. D	5½	1/16	"	7/8	0	1¼ × 16	.....	"
Baldwin Loco. Works....	1882	15.5	1,079	48	62	130	17 × 24	Unbal. D	5⅛	1/32	"	13/16	1/16 1	1⅛ × 16	.....	"
	1892..	17.6	1,536	58	69	160	18 × 24	Bal. D	5½	1/32	"	3/4	0	1¼ × 16	.....	"
Brooks Loco. Works.....	1882..	17	1,320	52	61 to 67	135	18 × 24	Unbal. D	5	1/8	"	3/4	0	1¼ × 16	.....	"
	1893	23 to 30	2,000 to 2,100	58 to 60	68 to 72	180	18 × 26 / 19 × 26	Allen bal.	6¼	1/64	"	1	1/16 to 1/32 1	1⅝ × 18½	.....	10-wheel

CHANGES IN DESIGN OF THROUGH FREIGHT LOCOMOTIVES, 1882-1893.

N. Y. Central & Hudson River R. R.	1882..	17.87	1,353	50	61	150	17 × 24	Rich. bal.	5¼	1/16	Increasing	7/8	1/8 1	15½ × 1¼	15½ × 2½	American
	1893..	29.8	1,763	58	57	160	19 × 26	"	5¾	1/16	"	7/8	1/32 1	18 × 1¼	18 × 3	Mogul
Michigan Central.....	1882..	16.2	1,063.5	48	63	135	17 × 24	Unbal. D	5½	1/32	"	3/4	1/16 1	1⅝ × 16	2½ × 16	American
	1893..	32.3	1,417.2	54	57	140	19 × 24	Bal. D	5½	1/16	"	7/8	1/32 1	1¼ × 16	2¾ × 16	Mogul
Chicago, Mil. & St. Paul	1882..	18.8	1,423	54	56	150	19 × 26	Plain bal.	5	1/16	"	3/4	1/32 1	1¼ × 16	3 × 16	10-wheel
	1893..	18.4	1,496	56	62	180	18 × 26	"	5½	1/16	"	3/4	1/16 1	1¼ × 17½	3 × 17⅝	10-wheel
Chicago, Burl. & Quincy	1882..	27½	1,165	56	60	145	20 × 24	Unbal. D	5	1/16	"	3/4	1/32 1	1¼ × 16	.....	Consol.
	1893	25	1,689	60	61	180	19 × 24	Allen bal.	5	1/32	"	7/8	1/16 clear	1½ × 17¼	.....	Mogul
Lake Shore & Mich. So'n	1882..	17	1,189	47	60	125	17 × 24	Plain D	5	1/8	Incr. to 11/32	7/8	0	1 × 15	.....	American
	1893..	22½	1,300	51	54	160	17 × 24	Bal. D	5½	1/8	"	1/4	1/16 1	1¼ × 15	.....	10-wheel
Chic., R. I. & Pacific.....	1882	15	1,000	50	57¾	135	17 × 24	Plain bal.	5½	1/32	Increasing	1	0	1¼ × 12	.....	American
	1893..	23.6	1,898	60	63¾	170	19 × 24	Allen bal.	5½	0	"	1	0	1¼ × 17	.....	10-wheel
Pennsylvania R. R.....	1882	23	1,260	54	50	125	20 × 24	Plain D	5	1/16	"	3/4	0	1¼ × 17¼	.....	Consol.
	1893..	31.5	1,498.3	60	50	110	20 × 24	Bal. D	5	1/16	"	3/4	0	1¼ × 17¼	.....	Consol.
Schenectady Loco. W'ks	1882..	17.1	1,079.4	50	55	130	18 × 24	Unbal. D	5	1/8	"	7/8	1/16 1	1⅛ × 16	.....	10-wheel
	1893..	27.8	1,895	58	64	170	19 × 26	Bal. D.	5½	1/16	"	3/4	0	1¼ × 18	.....	10-wheel
Baldwin Loco. Works ...	1882..	27.6	1,283	56	49	130	20 × 24	Unbal. D	5⅝	1/32	"	3/4	1/32 1	1¼ × 16	.....	Consol.
	1893..	33	1,967	64	50 or 52	160	21 × 26	Bal. D	5½	1/16	"	3/4	1/32 1	1⅞ × 16	.... ..	Consol.
Brooks Loco. Works.....	1882	17	1,300 to 1,500	52	56	135	18 × 24	Unbal. D	5	1/8	"	3/4	0	1⅜ × 15	.....	Mogul & 10-wheel
	1893	23 to 30	1,800 to 2,200	58 to 63	55 to 63	180	19 × 24	Plain and Allen bal.	6⅛	1/16 for Plain 1/32 for Allen	"	7/8 for Plain 1 for Allen	3/32 to 1/8 1	1⅝ × 18½	.....	Mogul, 10-wheel & Consol

The above shows that any of the simple engines were more economical in the use of steam than any of the compounds, whether two or four-cylinder, for high speed service. There are, it seems to me, reasonable explanations for this outcome. The economy of compounds is due mainly to three advantages they have over simple engines—greater expansion of the steam used, less loss by cylinder condensation, and a milder draft. The most important of these is probably the gain due to better expansion. I think it can be shown that they largely lose these advantages at high speeds, and, in addition, have certain disadvantages which simple locomotives do not have in so great a degree. By far the largest proportion of the work done by high speed passenger service, made by the C., B. & Q. and other roads, which are comparatively level. The results are stated in the pounds of water used in hauling one ton of cars one mile, as this represents the work done in the cylinders, and eliminates the influence of varying grate areas and heating surfaces :

Locomotive.	Ave. speed excl. stops. Mil. per hr.	Diam of drivers. Ins.	Water per ton mile of cars Lbs.	Weight of cars. Tons.
Simple, 18 × 24 ins....	43.2	69	1.02	318
19 × 24 ins.....	42.6	68	1.07	340
19 × 24 ins.....	43.1	62	1.06	367
Compound, 2-cylinder.	42.6	62	1.17	336
4-cylinder	42.3	72	1.10	388
4-cylinder	36.3	72	1.48	...

The above shows that any of the simple engines were more economical in the use of steam than any of the compounds, whether two or four-cylinder, for high speed service. There are, it seems to me, reasonable explanations for this outcome. The economy of compounds is due mainly to three advantages they have over simple engines—greater expansion of the steam used, less loss by cylinder condensation, and a milder draft. The most important of these is probably the gain due to better expansion. I think it can be shown that they largely lose these advantages at high speeds, and, in addition, have certain disadvantages which simple locomotives do not have in so great a degree. By far the largest proportion of the work done by

ferent, and the result is that, as a rule, the back-pressure of a compound locomotive is higher than of a simple at high speeds. If this fact and its reasonableness are admitted, it will explain why the compound loses at high speeds the mild draft it has at slower speeds. It would, therefore, seem evident that a compound is not necessarily as economical as a simple engine at high speeds, although it is admittedly so at slow speeds.

In this connection the following table is interesting, and indirectly confirms the arguments outlined above. It gives the indicated water per I. H.P. per hour, figured from a set of cards for a trip of a two-cylinder compound. The cards were taken at intervals of two minutes. The weight of the cars was 384 tons; engine and tender, 92 tons, making the total weight of the train 476 tons.

Two-Cylinder Compound Locomotive, 232.

Speed. Revs.	Miles per h. P. c.	Indic. water.	Average.
104	21.3	18.41	
120	24.7	17.45	
144	29.6	19.14	
148	30.4	17.98	
152	31.2	18.66.....	18.33
160	32.9	18.20	
168	34.5	19.87	
180	37.0	18.73	
184	37.8	19.72	
188	38.6	18.35	
188	38.6	18.51	

200	41.1	19.02.....	18.90
216	44.4	18.79	
228	46.9	18.00	
232	47.6	20.20	
236	48.5	19.92	
236	48.5	20.33	
240	49.3	20.71.....	19.7
256	52.6	21.01	
260	53.4	21.94	
268	55.1	18.90	
268	55.1	21.03	
268	55.1	22.35	
272	55.9	22.12	
272	55.9	22.44.....	21.4

The average indicated water for speeds between 100 and 150 revolutions per minute was 18.3 lbs.; between 150 and 200 revolutions was 18.9 lbs.; between 200 and 250 revolutions was 19.7 lbs., and between 250 and 275 revolutions was 21.4 lbs. This indicates strongly that the steam economy of this compound decreases as the speed increases, and that the economy decreases faster than the increasing speed after 150 revolutions per minute is reached. If it were necessary, I could show this to be true of three other compound locomotives, two two-cylinder and one four-cylinder. Cards from three compound locomotives show excessive compression, especially in the high-pressure cylinder. It is not to be wondered at that the compression is high, as the back-pressure is from 70 to 80 lbs. when the exhaust port closes. This excessive compression at high speed represents a loss in compound locomotives more serious than for simple engines, but the loss due to fall of steam pressure between the two cylinders is greater, and probably the most serious loss in compounds at high speeds. This loss is the difference in pressure between the back pressure line of the high-pressure card, and the steam and expansion line of the low-pressure card. At slow speeds this difference is not great, but increases with the speed. The reciprocating parts of compounds are heavier than those of simple engines, and, therefore, the counterbalance should be heavier.

The steam economy of well-designed, single expansion locomotives, as figured from indicator cards, increases as the speed increases within the limits of usual passenger train speeds. The following gives results computed from indicator card:

Revolutions.	Speed.— Miles per hour.	Indicated water, Lbs. per HP. hour.
151	31	21.70
219	45	20.91
253	52	20.52
307	63	20.23
321	66	20.01

It would be a mistake to assume that I do not believe in compounds. I believe they are the coming freight engine, and will prove more economical than simple engines in such service, or where, as in elevated service, most of the work is done in accelerating the trains to speed, or for passenger service on such lines as have heavy passenger trains and numerous hills where a large portion of the work is done while going up hill, the engine being shut off going down. The C., B. & Q. two-cylinder compound, which was about 30% less economical than simple engines of the same class when tested in passenger service, has since been shown to be 15% more economical in freight service than the best single expansion engine, and 29% more economical than the average record of 40 simple engines of the same class, in the same pool, and on the same division. In view of this, and other trustworthy records, there seems no escape from the conclusion that compounds are more economical than simple engines for certain kinds of work. It does not necessarily follow that they are, therefore, more economical for high speeds. As far as present experience goes, it is probable that the contrary is true where the road is comparatively level. There can be little doubt that compounds can be used more profitably in freight than in passenger service.

Compounds have certain advantages which they retain at high speeds which simple locomotives do not possess. For the same work, compounds use approximately twice as long a cut-off as simple locomotives, as the steam for two cylinders must be admitted through one—the high-pressure cylinder. For this reason the turning force at the crank pins is more uniform for compounds, and the steam is less wire-drawn during admission. It is probable that compounds can develop greater power at high speeds than simple engines. There certainly are some remarkable records made with heavy trains, weighing from 270 to 560 tons, hauled a distance of 55 miles, at average speeds from 50 to 60 miles an hour, and over a number of 36-ft. grades.

EDMUND GUNTER.

The measuring chain of 100 links, 66 ft. in length, is commonly called Gunter's chain, having been first used by him, and described in his treatise on the cross-staff, etc., in the following words: "We may measure the length and breadth by chains, each chain being 4 perches in length, and divided into 100 links, then will the work be more easier in arithmetic. For as ten to the breadth in chains, so the length in chains to the content in acres." Edmund Gunter, who belonged to Hertfordshire, was educated on the royal foundation of Westminster School, and elected from thence to Christchurch College, in Oxford, in the year 1599, being then 18 years of age, where he took the degrees in arts. Mathematics were the prevailing studies of his youth, and about the year 1606 he invented the sector, and wrote the description and use of it in Latin, many copies of which were taken in writing, but none of them printed. He obtained the professorship of astronomy in Gresham College in 1619. He died on Dec. 10, 1626 about the forty fifth year of his age.

The works of Gunter are as follows: 1. "Canon Triangulorum," London, 1620 (8vo) and 1623 (4to). A table of logarithmic sines, etc., to seven decimal places, the first of the kind which was published on Brigg's system of logarithms. 2. "Of the Sector, Cross-staff and other instruments" (first published in 1624). The invention of the sector, which now forms a part of every case of drawing instruments, as we have said, is due to Gunter. The cross-staff is not the surveying instrument now known by that name, but an instrument for taking angles, consisting of one straight line moving at right angles to another, with sights at their extremities. 3. "The Description and Use of His Majesty's Dials in Whitehall Garden," London, 1624, 4to. These dials (destroyed in 1697) were constructed by Gunter.

Gunter's writings (the "Canon Triangulorum" excepted) consist almost entirely of a description of graphical methods of constructing problems in trigonometry, navigation, etc. He was the first who laid down a logarithmic scale upon wood, and used it for the purposes of the draftsman. This scale is still used, and goes by his name. The first observation of the variation of the compass is due to Gunter. Ward infers this from a letter of Dr. Wallis to Sir Hans Sloane, attributing the observation to a Gresham professor about 1625, which could be no other than Gunter. Other writers mention the same discovery, but without stating their authority. Gunter is said to have been the first who introduced the words cosine, cotangent, etc., in place of sine of the complement, etc. In the preface of the "Canon" he speaks of the "sine of the complement, which in one word may be called the cosine," as if he were introducing a new word.—London "Architect."

PERSONALS.

Mr. John B. Wiltie has resigned his position as Roadmaster of the Belt Railway at Indianapolis.

Messrs. T. W. and Ross Morgan have opened offices as civil engineers at Oakland and San Francisco, Cal.

Mr. J. G. Mann, Assistant Engineer of the Illinois Central R. R., has been appointed General Manager of the Mobile & Ohio R. R.

Mr. H. M. Smith has been appointed General Master Mechanic of the St. Louis Merchants' Bridge Terminal Ry. He will have charge of Motive Power and Car Department.

Mr. James C. Hallsted, C. E., member of the firm of G. W. G. Ferris & Co., has removed from Chicago, and is now in charge of the firm's business in the east, with headquarters in Philadelphia, Pa.

Mr. W. G. Bailey has been appointed Superintendent of the Cairo Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., vice Mr. B. J. Sutton. He was formerly Engineer of Maintenance of Way and will combine the two positions.

Mr. H. F. J. Porter, M. Am. Soc. M. E., has formed a partnership with Mr. Albert Fisher and has opened an office in the Monadnock Block, Chicago, Ill. Mr. Porter was First Assistant Mechanical Engineer at the World's Columbian Exposition.

Mr. Loren T. Ladd has been made Commissioner of Public Works of Pawtucket, R. I., the water, sewer and highway departments of the city having been consolidated as the Board of Public Works, consisting of only one member with the title of Commissioner. Mr. Edwin Darling, for 14 years superintendent of the waterworks, will remain in office until Mr. Ladd becomes familiar with this department.

Mr. Austin Burt, of Detroit, Mich., who died recently at the age of 76, was the son of William Austin Burt, the inventor of the solar compass and Surveyor-General of Michigan. He came to Michigan in 1824, was one of the promotors of the Lake Superior Iron Co. and also interested in the Peninsular Iron Works and the Union Works. He was one of the original movers in the Detroit Transit Ry. Co. and was for many years president of the company.

Mr. E. F. Potter has been appointed General Manager of the Chicago, Fort Madison & Des Moines R. R., with headquarters at Fort Madison, Ia. Mr. Potter was formerly connected with the Chicago & Northwestern Ry. for about 15 years, and was Division Engineer of the Wisconsin and Milwaukee divisions. For the last three years he has been Superintendent and Chief Engineer of the railway of which he is now appointed General Manager.

Mr. John G. Tait has been engaged to examine the water power of the St. Louis River and submit plans and estimates for its development and transmission by electricity to Duluth, Minn., and Superior, Wis. Mr. Tait was the engineer for Rogers & Clement, the contractors for the Niagara water power tunnel, and since its completion he has been engaged with the Cataract Construction Co. as engineer in charge of the wheel pit, canal and power house construction.

NEW PUBLICATIONS.

MARCH MAGAZINES.—In the "North American Review," the U. S. Commissioner of Navigation, Hon. E. T. Chamberlain, urges the granting of American registry to foreign built vessels. Prof. Richard T. Ely writes on "Natural Monopolies and the Workingman," advocating government ownership and management of railways, telegraphs, telephones, canals, irrigation works, harbors and municipal monopolies, such as water supply, public and private lighting plants and street car lines. Hon. N. C. Blanchard describes the benefits which have resulted from the change in the method of appropriating for river and harbor works which was made in 1890. Sir G. S. Clark replies to Andrew Carnegie's recent paper advocating Commercial Union with Great Britain and proposes instead a "naval union" of the two countries.

In the "Forum" Simon Sterne has an interesting paper on "Recent Railroad Failures and Their Lessons." He propounds the novel idea that one cause for the recent crop of receiverships is the lack of men of the requisite ability to manage successfully the affairs of a gigantic railway corporation. He denounces the idea that the Interstate Commerce law has anything to do with the misfortunes of the railways and urges that more legislation, calculated to secure better and honester railway management is what is needed. "Nationalism" is discussed by Edward Bellamy and Prof. W. G. Sumner from diametrically opposite standpoints, and each shows so much intolerance that one is inclined to believe that the real truth lies between the two extremes, and that the limited "nationalism" which is rapidly growing among us is, for present conditions at least, a more sensible course than that urged by the extremists of either party.

In the "Review of Reviews" we find a brief account of the proposed new Arctic expedition under the leadership of Mr. Robert Stein, of the U. S. Geological Survey. In the "Century" we find a paper of great interest on "Earthquakes and How to Measure Them," by Prof. Edward S. Holden, of Lick University. "Harper's" article this month of most interest to engineers is a popular review of modern processes of steelmaking, written much more accurately and withal in a more entertaining vein than popular papers on technical subjects are apt to be. Dr. T. Mitchell Prudden, the well known bacteriologist, has a paper on "Tuberculosis and Its Prevention," a subject which is absorbing great attention at the present time.

In "Scribner's" is a short paper on "The Cable Street Railway," by Philip G. Hubert, Jr. It is chiefly devoted to describing New York's new cable railways on Broadway and Third Ave. A paper of much more interest and value is the "High Building and Its Art," by Prof. Barr Ferree. It is illustrated with engravings of a dozen or more of the most important "skyscrapers" of recent erection. Mr. Joel Chandler Harris, whose paper in last month's number on "The Sea Island Hurricanes" was noted in this column, describes in this number how relief was carried to the survivors. Still another paper in this magazine which deserves mention here is an interesting description of sub-tropical Florida by Chas. R. Dodge.

SEWAGE TREATMENT AND DISPOSAL.—For Cities, Towns, Villages, Private Dwellings and Public Institutions. By Thomas Wardle, Fellow of the Chemical Society, etc.; Chairman of the Standard Sewage and Water Purification Co., Limited. With Tables, Plans of Sewage Precipitation Works and Many Illustrations. Manchester, England: John Heywood. 8vo; pp. XVI., 426; 10 plates, 13 figures in the text and many tables.

This is the latest English work on the subject of sewage purification and continues with zeal abated little, if at all, the long-waged warfare in England over the relative desirability of simple land treatment and chemical precipitation. The author favors the latter supplemented with filtration through special material, and has both a chemical precipitant and a filtering medium of his own invention to advocate. But if the book is read with the somewhat partisan tendency and pecuniary interests of the author in mind, much may be learned from it which is not so fully presented in other English books on the subject.

A few of the leading English systems of sewage purification, more especially precipitation works, are described in detail, while more or less full returns by local officials from some 60 towns, given in brief form, present the more salient facts and figures regarding that number of English sewage purification works. There is also given a review of a large number of experiments with various systems of purification made at Salford, England. The biological side of the question is quite fully consid-

ered by the author; in fact it seems probable that too much stress is laid upon danger from various kinds of bacteria, but the information on these points is interesting and of undoubted value. The composition and growth of plants, soils and their nitrification, methods of sludge disposal and other matters more or less closely related to the subject are presented in the book. It remains to be added that a large part of the investigations were made in connection with a proposed sewerage scheme and the results were first published in a local paper in Leek, England, where Mr. Wardle lives.

THE BACTERIOLOGICAL EXAMINATION OF WATER.—A Paper Read Before the Annual Meeting of the British Institute of Public Health, July, 1893, by Percy Frankland, Ph. D., B. Sc. (Lond.), F. R.S., Professor of Chemistry in University College, Dundee, St. Andrews University. Reprinted by the author from the Journal of State Medicine, No. 7, Vol. II., January, 1894. Paper; pp. 15.

This is a brief and readable presentation of the broad general principles involved in the bacteriological examination of water and the practical value of the results from such studies. The highly beneficial effect of both sand filtration and simple storage, with its accompanying sedimentation, is forcibly stated in a few words. These fragmentary publications of Professor Frankland's writings prompt much anticipation of the large work on water bacteriology by Professor and Mrs. Frankland which it is expected will soon be issued.

WATER ANALYSIS.—On Some Recent Advances in Water Analysis and the Use of the Microscope for the Detection of Sewage Contamination. By Geo W. Rafter, Rochester, N. Y. Read Before the Buffalo, N. Y., Microscopical Club and Reprinted by the Author from the American Monthly Microscopical Journal for May, 1893; pp. 13.

This paper is commended to all interested in pure and safe water supplies. Absolute reliance upon chemical analyses is still retained by many whose positions make them the guardians of public water supplies, and thus to a large extent of the public health, but among the more advanced men who have to do with these important matters it is known that for water at all likely to be fit for domestic purposes chemical analysis is chiefly useful to indicate contamination or impurity from organic, human or animal wastes. In other words the chief danger from drinking water is that it may carry disease germs if polluted by organic matter. The microscope, Mr. Rafter shows in his paper, is a most indispensable adjunct in determining whether water has been polluted by sewage.

ENGINEERING EDUCATION. Being the Proceedings of Section E of the World's Engineering Congress, held in Chicago, Ill., July 31 to August 5, 1893. Published by the Society for the Promotion of Engineering Education as Vol. I. of their Proceedings. Edited by De Volson Wood, Ira O. Baker and J. B. Johnson, Committee. 8vo; pp. 342; $2.50. Address Prof. J. B. Johnson, Secretary, Washington University, St. Louis, Mo.

This volume is practically the official report of the proceedings of the International Congress of Engineering Education, held at the Columbian Exposition, and contains the full papers read at that congress and the discussions upon them. Though the intention was to make this an international congress, only one paper was presented from an educational institution outside of the United States, that of Mr. H. S. Hele-Shaw, Professor of Engineering in the University College of Liverpool, England, and the subject of this paper was "The Teaching of Graphical Methods in Engineering Schools and Colleges." Unfortunately for the broader discussion of questions relating to engineering education, the schools and methods of Germany, France and other European nations were totally unrepresented. Professor Swain, of the Massachusetts Institute of Technology, presented a paper comparing the American and European methods, but he prefaced his paper by the statement that time was lacking for a full investigation of the subject, and his paper was necessarily founded upon somewhat meager data. The other fifteen papers came from the most prominent American educators, or professors in engineering schools, and cover fairly, from the teachers' point of view, the requirements for properly teaching the various branches of engineering knowledge. The most prominent of the engineering schools were represented, with two or three exceptions, and the Massachusetts Institute of Technology had three papers out of the fifteen. Space here forbids even a brief review of the subject matter of these papers. But as one of the results of this congress is the organization of the Society for the Promotion of Engineering Education, the constitution of this society being given in this volume, it may here be said that a live interest has been awakened in this very important subject, and a careful comparison of methods, not only here, but abroad, should result in permanent benefit to our engineering schools.

REPORT OF THE BOARD OF RAILROAD COMMISSIONERS OF IOWA.—Sixteenth Annual Report; for the Year Ending June 30, 1893. Des Moines, Ia.; 8vo; pp. 326.

The report discusses the question of grade crossings at station grounds, where the view of the tracks is usually more or less obstructed by buildings and cars, and recommends legislative action to prevent the further increase of such crossings. The C., B. & Q. R. R. moved its yards from Creston on account of the number of accidents, and the C., R. I. & P. Ry. laid out extensive yards at Valley Junction, where the only highway across the land was changed so as to be safe. The owner of land south of the yard then tried to force the construction of a road across the railway company's property, but as the commissioners state, the "legislation is certainly defective if it cannot protect the owner of his property from this kind of intrusion." The report contains the condensed returns of the railway companies, cases submitted to them for decision, and an appendix with a list of the decisions of the board in all previous volumes.

REFERENCE BOOK OF RAILWAY SECURITIES.—White & Kemble, New York, N. Y. 8vo; pp. 526.

This is a useful book for brokers, railway men, etc., giving the mileage, termini, stocks and bonds, financial and traffic statements, etc., of about 1,600 railway companies. The details are given not only of the funded debt and capital stock of each road comprising the system in each case, but also the amount of each issue per mile, while the mileage, forming the basis of calculation, is also indicated. Double track and sidings are given, to indicate the value of the property. For instance the Pennsylvania R. R. is shown to own and control 7,868 miles of single track bonded for $36,611 per mile, with capital stock issued to the extent of $31,791 per mile; while the New York Central R. R. has 2,809 miles of single track, bonded for $59,799 per mile, with capital stock at $45,907 per mile. This would seem at first to show an advantage for the former road, but the statement further shows the Pennsylvania R. R. to have only 1,273 miles of additional track to 7,868 miles of road, while the New York Central has 1,535 miles of additional track to 2,809 miles of road. The arrangement is clear and concise, and the book is well printed on paper sufficiently thin to avoid making a bulky volume.

TRADE PUBLICATIONS.

MATHEMATICAL ENGINEERING INSTRUMENTS.—Supplies for Architects and Surveyors. Manufactured and Imported by Schwencke, Kirk & Co., 26 Church St., New York. Paper; pp. 128; many illustrations.

This is a priced catalogue of nearly everything in the way of architects' and engineers' supplies.

SOCIETY PROCEEDINGS.

LIVERPOOL ENGINEERING SOCIETY.—At the meeting on Feb. 4 a paper was read by Mr. James Morgan, Chief Surveyor of Roads to the Liverpool Corporation, on "Street Pavements," dealing exclusively with the impervious pavements laid under the author's supervision in Liverpool since 1872. The question of subways for water, gas, telegraph and other mains was dealt with, and the desirability of such provision in the streets was shown by the fact that in 1892 and 1893 $45\frac{1}{2}$ and $40\frac{1}{2}$ miles respectively of trenches were cut for these purposes in the carriageways and footways of Liverpool. The author concluded by stating that in 1882 there had been laid 650,000 sq. yds. of impervious pavements in Liverpool, and that there are now 1,810,948 sq. yds. of this class of pavement.

BOSTON SOCIETY OF CIVIL ENGINEERS.—The annual dinner of the society was held on March 6, about 120 members and guests being present. After dinner the president, Mr. John R. Freeman, M. Am. Soc. C. E., called the meeting to order. He stated that this society is the oldest civil engineering society in the country, having been started in 1848, and is now in a prosperous condition, having a membership of about 330 and an average attendance at the monthly meetings of from 75 to 100.

Prof. F. R. Hutton, Secretary of the American Society of Mechanical Engineers, was introduced. He stated that the engineer of to-day works under circumstances much different from the engineer of the older days. To-day there is much accumulated experience and experimental data at his disposal. This makes mistakes much less likely to occur, but much less excusable when they do occur. He noted the present tendency to specialize. In 1877 Columbia College easily found a professor of engineering who cared for all the departments, but in 1893 several men were necessary to cover the same field. Many engineers are now employed by large corporations, who claim the ownership of all expense and experimental data accumulated by these men, and often forbid its publication. This is a danger and tends to deprive engineering science of needed experience.

Mr. H. M. Howe, the retiring president of the American Institute of Mining Engineers, made some remarks upon steel. He noted its possible variable qualities from the hardness of glass to great softness. His message to the civil engineers was that the mining engineers desired to know the exact properties that were needed in the steel they used.

John C. Trautwine, Jr., Assoc. Am. Soc. C. E., brought the greeting from the Engineers' Club of Philadelphia. Prof. Ira N. Hollis, of Harvard University, head of the Engineering Department of the Lawrence Scientific School, spoke of the new dispensation, the increased respect of the associated faculties and the determination of President Eliot that this should in no way be second to any department of the university. There are now 280 men in school, and there are hopes of future enlargement and every prospect that the school will push ahead.

Mr. W. L. Parker, Manufacturing Agent of the Pacific Mills, Lawrence, Mass., was introduced as a representative of the captains of industry and spoke of the industrial engineers. He noted that almost every branch of engineering was represented in the building or in the running of a large factory like the Pacific Mills.

Prof. W. T. Sedgwick, of the Massachusetts Institute of Technology, told of the work of the Massachusetts State Board of Health. He spoke particularly of the municipal water filter at work at Lawrence since last October, and stated that Mr. H. F. Mill, the engineer member of the board, deserved much credit for the success of their undertaking, which has caused a great decrease of typhoid fever in Lawrence.

Prof. Geo. F. Swain, of the Massachusetts Institute of Technology, a member of the Boston Subway Commission, described in brief the plans of the commission to free the streets of the present crowded car traffic, and at the same time secure a measurable degree of rapid transit.

The secretary of the State Metropolitan Park Commission described the work done by that body. The Blue Hill reservation of 4,000 acres and the Middlesex Falls reservation of 3,000 acres are already nearly fully secured. The aim is to keep these reservations in their wild state and preserve them as free-roaming grounds for the people forever. It is also proposed to still further extend the system, especially by securing one of the beautiful beaches just outside the city limits.

The speechmaking was ended by a few remarks from Mr. Desmond Fitz Gerald, M. Am. Soc., C. E., and Mr. Henry Manley, M. Am. Soc. C. E., members of the society.

COMING TECHNICAL MEETINGS.

MONTANA SOCIETY OF CIVIL ENGINEERS.
March 10. Secy., G. O. Foss, Helena.
WISCONSIN POLYTECHNIC SOCIETY.
March 12. Secy., M. F. Schinke, City Hall, Milwaukee.
CIVIL ENGINEERS' CLUB OF CLEVELAND.
March 13. Secy., F. C. Osborn, Case Library Building.
NORTHWEST RAILROAD CLUB.
March 13. Secy., W. D. Crosman, Ryan Hotel, St. Paul.
NORTHWESTERN SOCIETY OF ENGINEERS.
March 13. Secy., D. W. McMorris, Burke Block, Seattle, Wash.
DENVER SOCIETY OF CIVIL ENGINEERS.
March 13. Secy., F. E. King, Jacobson Block.
CIVIL ENGINEERS' ASSOCIATION OF KANSAS.
March 14. Wichita, Kan.
NEW ENGLAND RAILROAD CLUB.
March 14. Secy., F. M. Curtis, P. O. Box 1576, Boston.
AMERICAN SOC. OF MECHANICAL ENGINEERS.
March 14. Secy., F. R. Hutton, 12 W. 31st St., New York.
CANADIAN SOCIETY OF CIVIL ENGINEERS.
March 15. Secy., C. H. McLeod, Montreal, P. Q.
ENGINEERS' CLUB OF CINCINNATI.
March 15. J. F. Wilson, 24 W. 4th St.
NEW YORK RAILROAD CLUB.
March 15. Secy., John A. Hill, Temple Court.
SCANDINAVIAN ENGINEERING SOC. OF CHICAGO.
March 15. Secy., Howard Berge, 100 Washington St.
TACOMA SOC. OF ENGINEERS AND ARCHITECTS.
March 16. 201 Washington Building.
NORTHWESTERN TRACK AND BRIDGE ASSO'N.
March 16. Secy., D. W. Meeker, St. Paul.
ENGINEERS' CLUB OF PHILADELPHIA.
March 17. Secy., L. F. Rondinella, 1122 Girard St.
SWEDISH ENGINEERS' CLUB.
March 17. Secy., P. Valentine. At 231 Union St., Brooklyn, and 646 North 10th St., Philadelphia. At 106 Randolph St., Chicago. Secy., C. T. Anderson.
ENGINEERS' CLUB OF MINNEAPOLIS.
March 19. Secy., E. Nexsen, 504 Kasota Block.
ENGINEERS' SOC. OF WESTERN PENNSYLVANIA.
March 20. Secy., R. H. Clark, Pittsburg.
WESTERN RAILWAY CLUB.
March 20. Secy., Clement F. Street, Rookery, Chicago.
COLUMBIAN ENGINEERING SOCIETY.
March 20. Secy., F. W. Hart, Washington, D. C.
ENGINEERS' CLUB OF ST. LOUIS.
March 21. Secy., Wm. H. Bryan, Turner Bldg.
AMERICAN SOCIETY OF CIVIL ENGINEERS.
March 21. Secy., F. Collingwood, 127 E. 23d St., New York.
BOSTON SOCIETY OF CIVIL ENGINEERS.
March 21. Secy., S. E. Tinkham, 36 Bromfield St.
ASSOCIATION OF ENGINEERS OF VIRGINIA.
March 21. Secy., J. A. Pilcher, Roanoke, Va.
CENTRAL RAILWAY CLUB.
March 28. Secy., S. W. Spear, Buffalo, N. Y.
CIVIL ENGINEERS' SOCIETY OF ST. PAUL.
April 2. Secy., C. L. Annan, City Engineer's Office.
ENGINEERS' SOCIETY OF PHOENIXVILLE.
April 3. Secy., W. Halliburton.
WESTERN SOCIETY OF ENGINEERS.
April 4. Secy., Thos. Appleton, Lakeside Bldg., Chicago.
ASSOCIATION OF CIVIL ENGINEERS OF DALLAS.
April 6. Secy., E. K. Smoot, 803 Commerce St.
TECHNICAL SOCIETY OF THE PACIFIC COAST.
April 6. Secy., O. Von Geldern, 719 Market St., San Francisco.
AMERICAN RAILWAY ASSOCIATION.
April 11. Secy., W. F. Allen, 24 Park Place, New York.
ENGINEERING ASSOCIATION OF THE SOUTH.
April 12. Secy., Hunter McDonald, Nashville, Tenn.
ENGINEERS' AND ARCH'TS CLUB OF LOUISVILLE.
April 12. Secy., F. W. Mowbray, Norton Building.
ENGINEERS' CLUB OF KANSAS CITY.
April 14. Secy., Waterman Stone, Baird Building.
SOUTHERN & SOUTHWESTERN RAILWAY CLUB.
April 19. Secy., S. A. Charpiot, Macon, Ga.
MASTER CAR BUILDERS' ASSOCIATION.
June 12, 16. Saratoga, N. Y. Secy., J. W. Cloud, Rookery Building, Chicago.
MASTER MECHANICS' ASSOCIATION.
June 19, 23. Saratoga, N. Y. Secy., Angus Sinclair, Temple Court, New York.

ENGINEERING NEWS

AND

AMERICAN RAILWAY JOURNAL.

Published Weekly at Tribune Building, New York. Entered at the Post Office, New York, as Second Class Matter.

VOL. XXXI. THURSDAY, MARCH 8, 1894.

D. McN. STAUFFER, A. M. WELLINGTON.....EDITORS
CHAS. W. BAKER, E. E. R. TRATMAN, M. N. BAKER.....ASSOCIATE EDITORS
GEO. H. FROST.....BUSINESS MANAGER
F. P. BURT.....ASSISTANT MANAGER

CHICAGO OFFICE: 1,636 The Monadnock.
CHAS. S. HILL.....RESIDENT EDITOR
F. A. PECKHAM.....ADVERTISING MANAGER

EUROPEAN AGENCIES:

KEGAN PAUL, TRENCH, TRUEBNER & Co. (Limited), Paternoster House, Charing Cross Road, London, Eng
SAMPSON LOW, MARSTON & Co. (Limited), St. Dunstan's House, Fetter Lane, London, Eng.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 2 months, $1.00; single copies, 15 cents. To all other countries in the Postal Union, add $2.08 per annum (4 cents per number) to above prices for postage. No club rates allowed. Mailing addresses may be changed at will by sending both old and new address. We shall be obliged if subscribers who fail to receive their papers promptly will notify us without delay.

The date when the subscription expires is on the address label on each paper; the change of this to a subsequent date is the only receipt sent, unless by special request.

ADVERTISING RATES: 20 cents per line agate measure. Want notices, special rates, see page 22. Rates for standing advertisements sent on request. Changes of advertisements must be in hand on Monday afternoon; new advertisements, Tuesday afternoon; transient advertisements by Wednesday noon.

In our issue of March 1 was an article based upon a paper lately read by Mr. J. S. Jeans, showing that since 1877 the United States had far outstripped all other nations in the quantity of iron and steel produced; the production in 1892 equaling over 35% of the world's total output. The changed relations between England and the United States are particularly noticeable in this period of 1877-1892; the United States having advanced in that period from 15.3 to 35.2% of the world's output of pig iron, and England having fallen from 48.9 to 25.4% in the same time. But in addition to having the largest output of ore and pig iron the United States can now defy foreign competition in the cost of manufacture, according to the latest figures from the wonderful ore deposit in the Lake Superior iron region. We are told that within the past week over 800,000 tons of ore have been sold from the Chandler and Mesaba mines, for delivery within the present year, at from $2.25 to $2.95 per ton delivered at Cleveland or other lower lake ports. The Chandler ore is guaranteed at 63% and the Mesaba ore at 62% of metallic iron, and both are strictly Bessemer ores. The following statement as to the cost per ton is interesting as showing the extreme economy with which these ores are mined and transported over 880 miles to the eastern points of distribution and use:

Per ton.	Chandler.	Mesaba.
Rail freight, mines to lake.....	$0.95	$0.80
Lake freights	.85	.85
Insurance and commission	.15	.15
Royalty	.30	.25
Cost of ore on cars at mines.....	.70	.20
Totals	$2.95	$2.25

To these figures $1.05 per ton must be added for rail freight to the furnaces of Pittsburg, Pa.; but with these ores at Pittsburg pig iron can be made at $8.50 per ton, according to good authority.

These figures furnish a basis for the price of iron and steel products during the present year; and as further evidence of what they mean the fact is pointed out that one Pittsburg firm has recently sold steel plates for use in shipbuilding for $1.15 per 100 lbs. delivered in Philadelphia, and plates for bridge construction are freely offered on the same terms. This is but little over one cent per pound delivered at the seaboard 350 miles from the mill. It is interesting to note that the distance from the Lake Superior mining regions to Cleveland, O., is about 880 miles, of which distance about 100 miles is by rail to the lake and the remainder is lake transportation. The average ton-mile rate over the railway was 1.18 cts. in 1883 and is little less than one cent now, according to the figures here given. The lake rate of 85 cts. for nearly 800 miles of transportation is but little over one-tenth of the railway rate per ton. The Duluth & Iron Range R. R. Co. made a return of 57.37% net earnings in 1893, almost wholly on its iron ore traffic; and if forced to it could evidently reduce considerably further the ton-rate for freight to the lake. With Bessemer ore in inexhaustible quantity, so situated as to be mined with steam shovels, and facilities for transportation already so developed as to afford a ton-rate averaging only three-tenths of a cent to the furnaces and mills of Pittsburg, it is somewhat difficult to fix limits to the immediate future of the iron and steel trade of the United States.

Verily, the way of those who are striving to enforce the Interstate Commerce law is a difficult one. The power of the Commission to detect and punish violations of the law has been steadily whittled away by one court decision after another, and the latest decision of Judge Grosscup, excusing witnesses from testifying on the ground that they might thereby incriminate themselves, makes the detection and punishment of transgressors of the law a wellnigh hopeless task. As the case stands now, the law on the statute books forbids discriminations of all forms, things which every intelligent student of the relations between the railways and the public knows are utterly bad and ought to be wiped out. Virtually the law says to the railway companies, you must treat all men, all parties, all interests, all localities, with equal and even justice, and you must not use your power to build up one man, one firm, or one city at the expense of and injury of another. The essential fairness and justice of this requirement must be admitted, and close students of the problem are aware that this requirement is hardly less important for the protection of the railway company from decrease of revenue, and especially for the protection of the stockholders from loss by peculation on the part of the minor officials of the company, than it is for the protection of the public from injustice.

The continued defiance of this feature of the law is most discreditable to every railway official who has the power to stop it and does not do so. Something can be said against the long and short haul clause of the law, and a great deal can be said against its anti-pooling section; but the prohibition of unjust discriminations appeals to every man as being fair and right.

Perhaps Judge Grosscup's recent decision may be welcomed by a certain class of railway managers as a signal to throw off all restrictions and "get business; honestly, if they can, but get it." Their agents can doubtless cut rates and give secret rebates at will without the fear of a prison cell; but the reckoning will come eventually and between the owners of railway property whose interests are thus ruthlessly sacrificed, and the public whose authority is defied and set at naught, a better and honester administration of railway traffic departments is certain to be brought about.

The valuable paper on the distribution of steam in high-pressure locomotives, which is printed in another column, presents the best summary of the advance made in the past decade in the steam engineering features of the locomotive that we have anywhere seen. The widespread demand for fast trains for both passenger and freight transportation is largely a growth of the past decade. It was formerly supposed that the power absorbed in hauling trains increased very rapidly with the speed, and that three or four times as many foot-pounds of energy were used in hauling a train a given distance at 50 miles per hour as were used in hauling it the same distance at 25 miles per hour. More recent tests on passenger trains at very high speeds (Eng. News, June 9, 1892), have showed that instead of the train resistance at high speeds increasing as the square of the velocity it increases only as its first power and for passenger trains at speed, resistance in pounds per ton = ¼ velocity in miles per hour + 2. According to this formula, the resistance of a train at 60 miles per hour is only 50% greater than at 30 miles per hour, and hence only 50% more work is done in making a given run with a high-speed train than with a train at low speed. But while this means the burning of a half more coal per train-mile, there are economies in the higher speed which may much more than offset the increase in the fuel bill. To double train speed means that double the amount of work per day is done by rolling stock and by trainmen; and while the latter are frequently paid by the mile, the wage schedule is really made up on the basis that at average train speeds the employees will earn fair wages for time spent. Thus the movement toward higher speeds for both passenger and freight traffic, which has gone on with especial rapidity during the past decade, is really a gain in the economical handling of traffic and not, as has been often assumed, a movement to meet demands of shippers and passengers without regard to its effect on operating expenses.

But while only 50% more foot-pounds of work must be done to move a train at 60 miles per hour than at 30 miles, this work must be done in half the time, hence on a level, straight track a locomotive must develop three times the horse power to haul a train at the higher speed that is required for the lower. This, with the added length of trains which are now hauled, compared with that of a dozen years ago, is sufficient explanation for the rapid increase in the power of locomotives which has been going on, as shown by the table in another column. The first demand has been on the boiler, and to meet it steam pressure has been raised and grate area and heating surface have been greatly increased. By these changes a much increased volume of steam is furnished at higher pressure, and Mr. Quereau has explained how the skilled locomotive designer of the present day attempts to use this steam so as to obtain the greatest possible power from it before discharging it from the stack.

In the first place, the still common practice of regulating speed by the throttle must be strictly prohibited and the prohibition must be enforced, if economy is to be secured. In the second place, increased size of drivers reduces the piston speed necessary for a given velocity of train. In the third place, it is the business of the valves and valve gear to get the steam into and out of the cylinder with as little loss as possible through the friction of the steam in the passages. This is accomplished by the use of improved valves, having increased travel, over longer ports of greater area, and by so adjusting the valve gear that at high speeds the steam shall anticipate the wants of the cylinder, yet without obstructing its action by overcompression.

On the much-discussed subject of the merits of compound locomotives in fast passenger service, the author cites tests which showed that no gain was found over simple engines, and apparently accepts the idea that the compound locomotive can be set down as a much more economical machine than the simple for freight service, but as no improvement over it for fast passenger service. It is doubtful whether this dictum will stand very long. The gain by compounding is now well understood to be due, first, to the reduction of the loss by cylinder condensation, and, second and incidentally, to the saving in coal due to a milder blast from the exhaust nozzle. If it can be shown that the simple locomotive does not have a material loss from cylinder condensation when running at very high speeds the claims of the compound need not be further considered; but experience in stationary practice seems to show that even at very high speeds condensation in the cylinder due to the difference in temperature of the entering and escaping steam is an important source of loss, and apparently there is no reason why it should be less in a locomotive cylinder.

It may be true perhaps that with present forms of locomotive valves and valve motions steam cannot be expanded through two cylinders behind fast-running pistons without a loss by "clogging" which will offset the gain by reduced cylinder condensa-

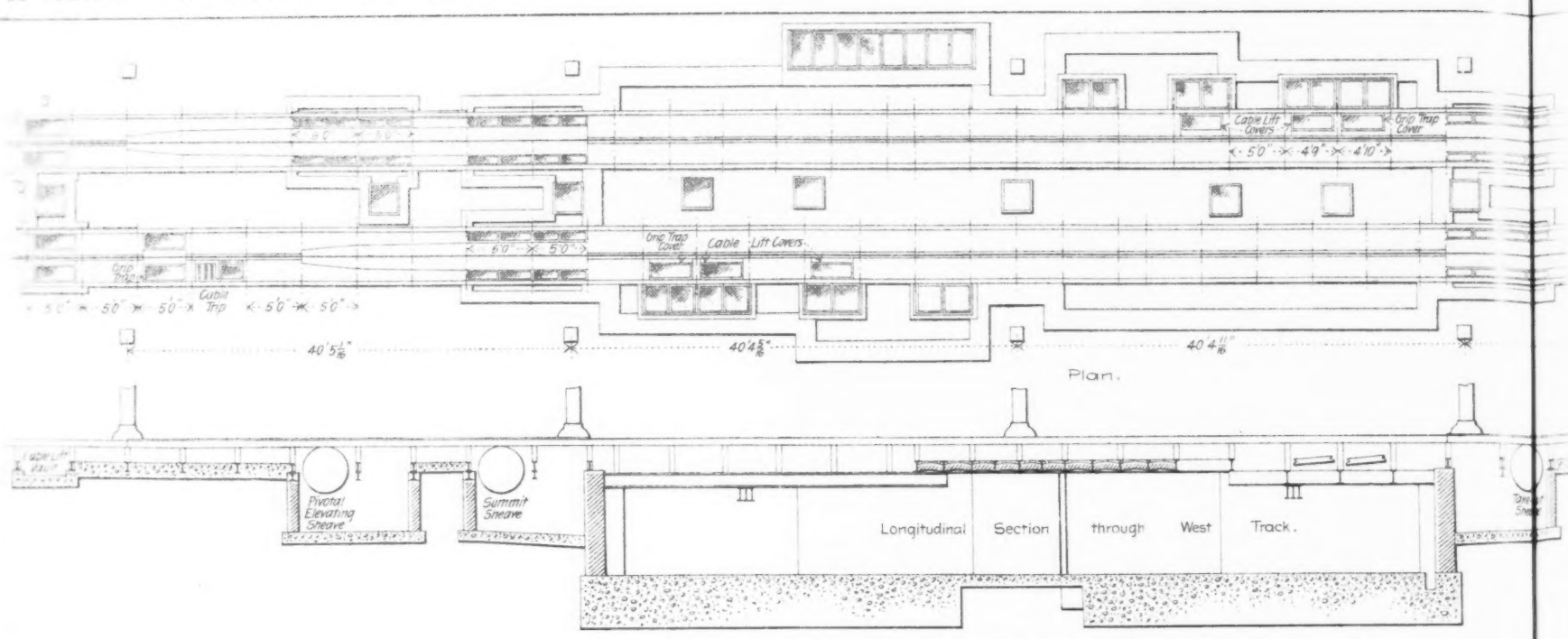


FIG. 3. PLAN AND SECTION OF TERMINAL WHEEL VAULT, AT SIXTH ST.

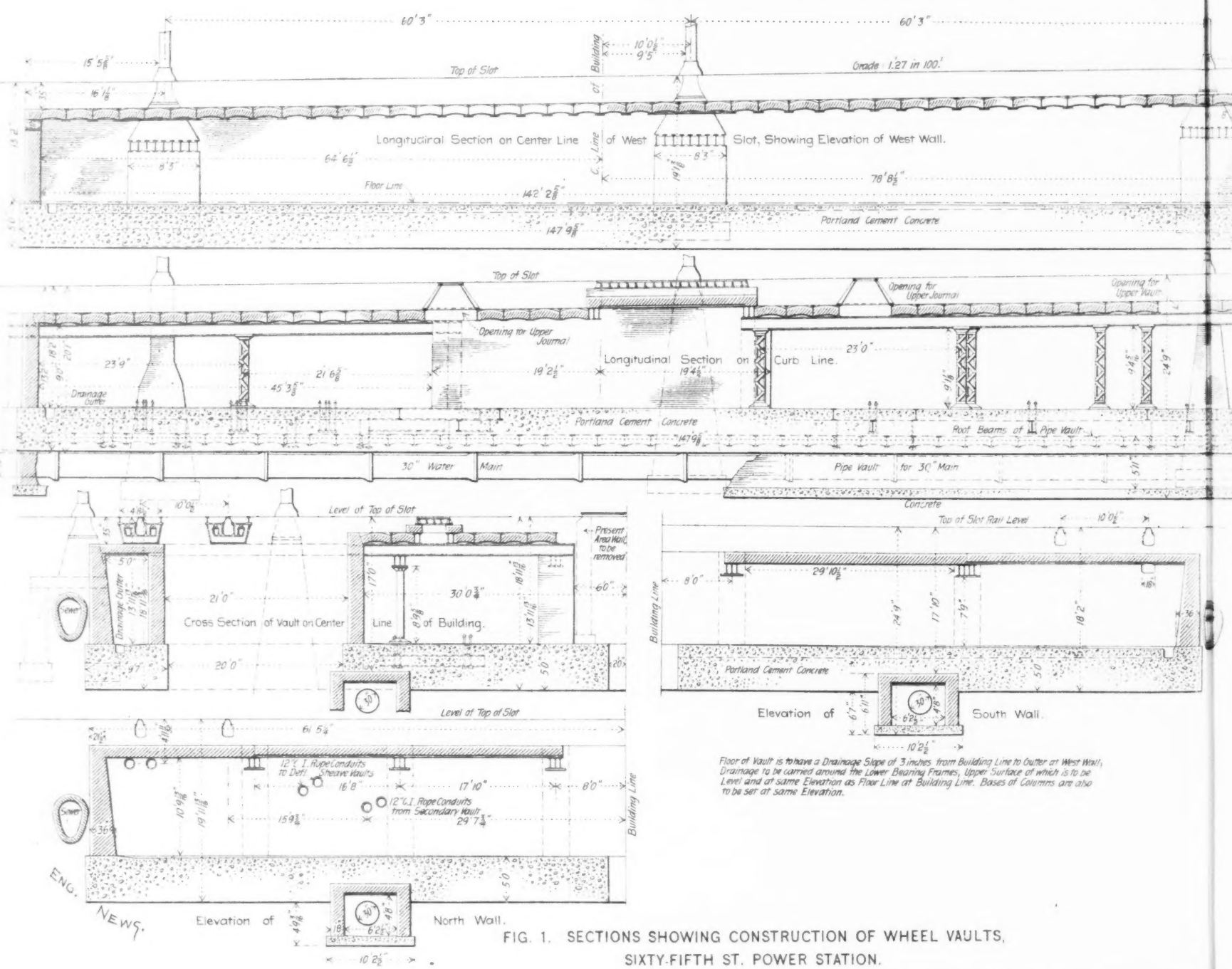
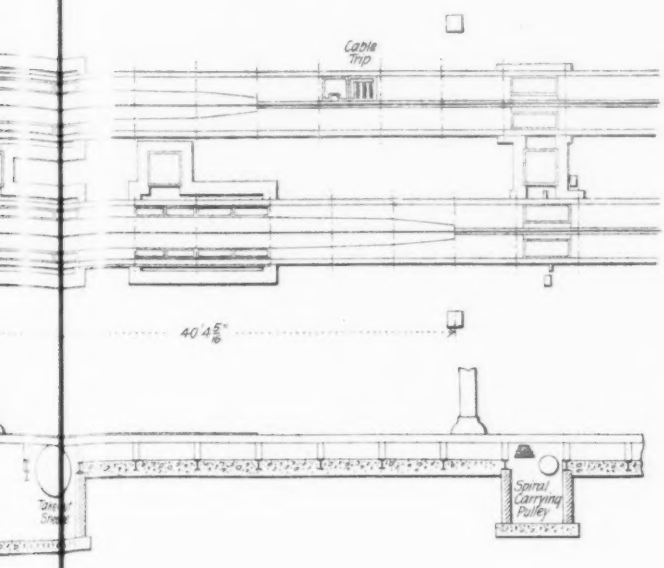
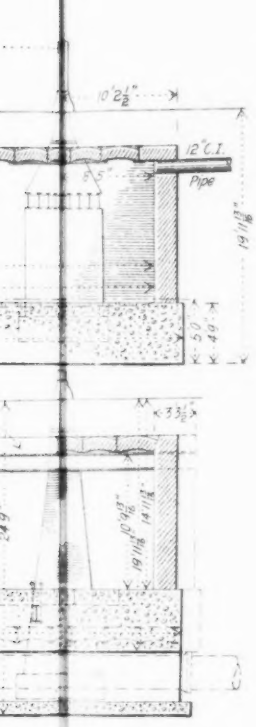

Top of Slot
Building
Grade 1.27 in 100.
Longitudinal Section on Center Line of West Slot, Showing Elevation of West Wall.
Floor Line
Portland Cement Concrete
Opening for Upper Journal
Longitudinal Section on Curb Line.
Drainage Gutter
Root Beams of Pipe Vault
30" Water Main
Pipe Vault for 30" Main
Concrete
Level of Top of Slot
Present Area Wall to be removed
Cross Section of Vault on Center Line of Building.
12" C.I. Pipe Conduits to Deflecting Sheave Vaults
12" C.I. Pipe Conduits from Secondary Vault
Building Line
Elevation of North Wall.
Top of Slot Rail Level
Elevation of South Wall.
Floor of Vault is to have a Drainage Slope of 3 inches from Building Line to Gutter at West Wall. Drainage to be carried around the Lower Bearing Frames, Upper Surface of which is to be Level and at same Elevation as Floor Line at Building Line. Bases of Columns are also to be set at same Elevation.

FIG. 1. SECTIONS SHOWING CONSTRUCTION OF WHEEL VAULTS, SIXTY-FIFTH ST. POWER STATION.

THIRD AVENUE CABLE RAILWAY; DEFLECTING SHEA

J. H. Robertson, Superintendent.





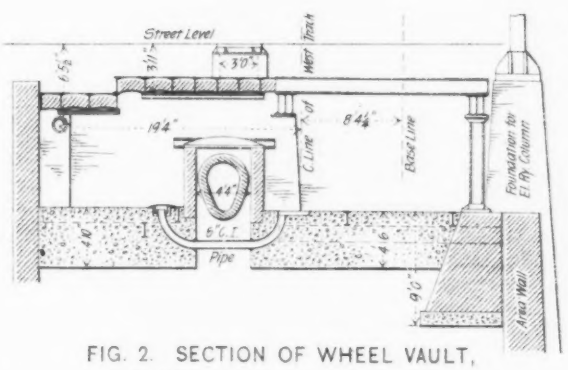
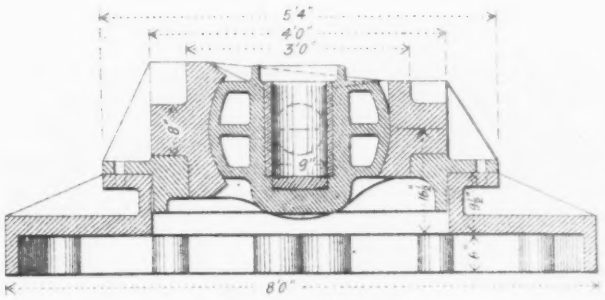
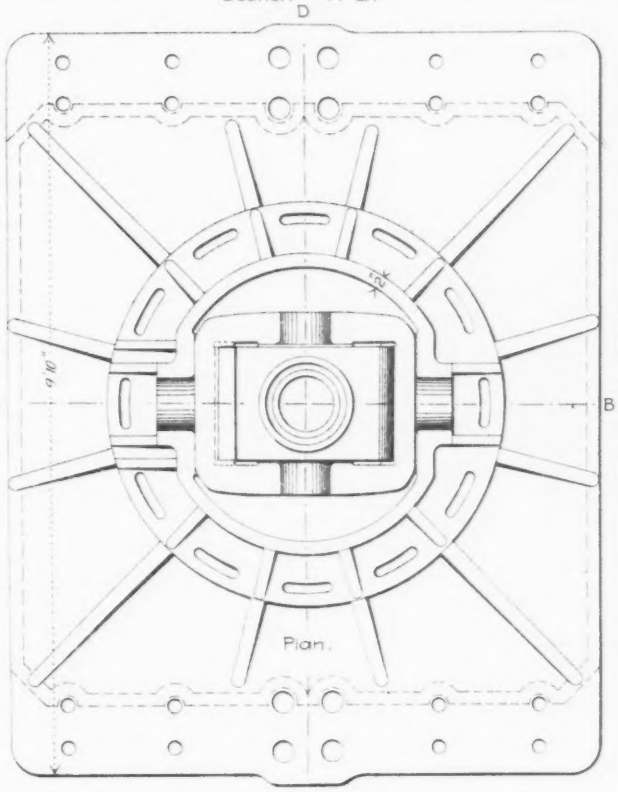
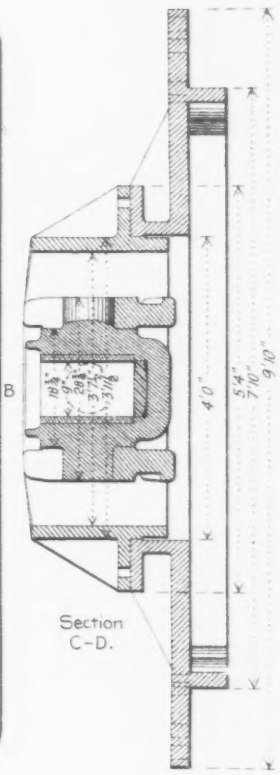


FIG. 2. SECTION OF WHEEL VAULT, BAYARD ST. POWER STATION.



Section A-B.





Section C-D.

FIG. 7. PLAN AND SECTION OF LOWER GIMBAL BEARING FOR 15 FT. DEFLECTING SHEAVE.

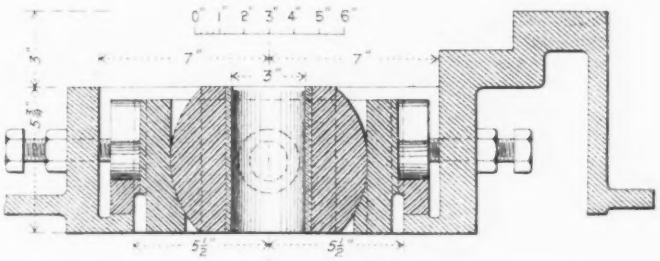


FIG. 4. SECTION OF UPPER GIMBAL BEARING, CHATHAM SQUARE CURVE PULLEY.

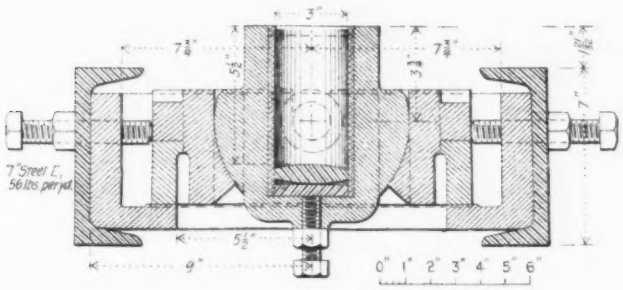
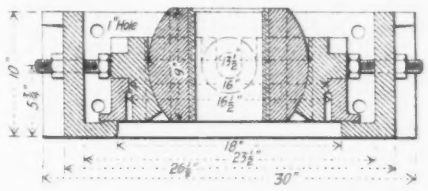
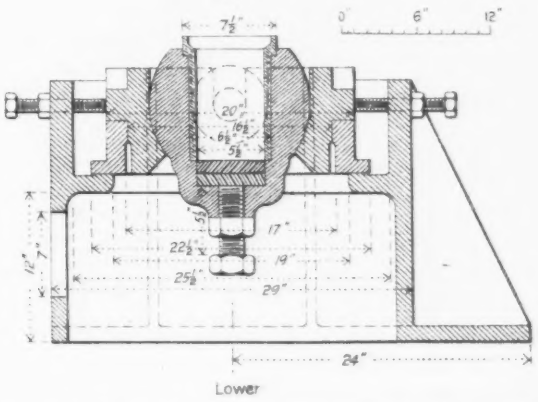


FIG. 5. SECTION OF LOWER GIMBAL BEARING, CHATHAM SQUARE CURVE PULLEY.



Upper.



Lower

FIG. 6. SECTIONS OF UPPER AND LOWER GIMBAL BEARINGS FOR 6 FT. DEFLECTING SHEAVE AT SIXTH ST.

SHEA VAULTS AND DETAILS OF PULLEY BEARINGS.

ent. H. Lighthall, Chief Engineer.

CHAS. HART & SONS, LITH., 35 VESEY ST., N. Y.

tion; but the possibility still remains that a better distribution of the steam can be effected which will overcome this objection. It will be well not to make a final rejection of the compound principle for fast passenger service until the possibilities in this direction are exhausted.

A special bill is now before the U. S. Senate relating to an increased appropriation to be expended on further United States timber tests. This bill has been referred to the Committee on Agriculture and Forestry and is now in the hands of a sub-committee made up of Senators Roach and Proctor. This sub-committee is asking for information regarding the necessity for this work and the popular demand for these tests, and the time is thus at hand for every engineer and every individual interested in the continuance of these important tests to use all influence at their command to further this good work; to collate and forward to the sub-committee all data bearing upon the subject and to endeavor in every legitimate way to convince these Senators of the real and live importance of furnishing the means for continuing and still further extending these tests of American timber. The work already done, though limited in extent, has paid enormous returns upon its actual cost in the new light thrown upon the value of the "bled" pine timber of the South; and this is only one valuable result out of many. The tests to be made are of such a character that they can be properly conducted only as government work; and the comparatively small outlay demanded is quite as legitimate an expenditure of public funds as is the money spent in opening a harbor or deepening a river channel. In fact, the benefits to be obtained from them are much more far-reaching and effect a greater proportion of the whole people than does any individual river or harbor improvement requiring an equal amount of money.

As yet the U. S. Government has spent but little money on these tests. They were only authorized about three years ago, and for the first year a very little money was set aside from the regular Forestry Division appropriation. The second year a special appropriation of $2,000 was made; and for the third year (1893) a bill appropriating $40,000 was introduced, but failed to pass owing to those interested not exerting themselves in time. As it was, $12,000 only was added to the department bill. One end greatly to be desired, and one of the purposes of the more liberal appropriations now asked for, is the establishment of a testing laboratory on the Pacific Coast for testing the valuable and abundant timbers of that region. These are "troublous times" in matters financial, and the government is compelled to observe due economy in appropriations. But it is the duty of every citizen, and especially of every engineer and architect, to use his best endeavor to enlighten those intrusted with making appropriations, and to see to it that this timber test fund does not suffer from motives of false economy due to ignorance of the valuable results to be arrived at. As already remarked, the importance of the work already done to the multitude of users of timber is out of all proportion to the paltry sum expended in obtaining them, and every consideration of economy and a better understanding of the qualities and uses of our enormous timber supply point to the extension of these experiments as both wise and proper.

The Greater New York bill has passed both branches of the New York Legislature, has been signed by the Governor and the people of the district affected will now be enabled to declare by a popular vote whether or not the majority really wishes this consolidation of interests. There is considerable conflict among the newspapers of New York as to the actual area included in the Greater New York; some giving this area as 125 sq. miles and others as 317.8 sq. miles. This journal also assumed the smaller area in editorially speaking of it some weeks ago; but by an actual measurement of the section as defined in the bill we now find that we were in error, and that the larger figure is nearer the truth. The real area of land and water included within the boundaries laid down in the Act is about 676 sq. miles; but the land taken alone aggregates about 318 sq. miles, as near as can be made out from the very vague boundaries given in the bill. Considerable change has been made in the north boundary since consolidation was first discussed and Yonkers is not included in the present scheme. The northern limit of New York, as now existing, is continued from the Bronx River to the middle of the channel between Hunters and Glen islands, in Long Island Sound. And on Long Island is included all that part lying "westerly of a straight line drawn from the southeasterly point of the town of Flushing, through the middle of the channel between Rockaway Beach and Shelter Island, to the Atlantic Ocean." This area, of course, includes Brooklyn, Flushing, Newtown, Jamaica, etc., and the part of Hempstead lying west of the line fixed. The whole of Staten Island is also taken in. According to the most recent census available this area of 318 sq. miles now includes a population of about 2,965,800. This same area had in 1870 a population of about 1,450,000, and in 1880 a population of about 1,850,000.

This total land area of 318 sq. miles may be subdivided as to areas and population about as follows: New York, including all between the Hudson and the East River and the Sound, about 61.8 sq. miles, with an estimated population of about 1,820,000; Staten Island, or Richmond Co., 58.5 sq. miles, with about 53,450 inhabitants, and very nearly 200 sq. miles on Long Island, with a total population of nearly 1,100,000. Over these main subdivisions the density of population is about as follows: New York, nearly 30,000 per sq. mile; the Long Island section averages 5,460 per sq. mile, though this includes 29 sq. miles of Brooklyn, with a density of 33,000 per mile; and Staten Island has an average of only 900 per sq. mile. Taken as a whole Greater New York would have an average density of population of 9,300 per sq. mile, as compared with 8,200 for each of the 688 sq. miles of the Metropolis of London. In aggregate population London would alone outrank the Greater New York; the English city having 4,211,056 inhabitants according to the last census. Paris, in 1891, had a population of 2,447,957, and is thus outranked by the later New York. Of the other great cities of the world, Berlin has over 1,600,000; Tokio and Vienna have at least 1,300,000 each; and Canton, China, was credited with 1,600,000 several years ago. The exact population of Chicago, the would-be rival of New York, is difficult to state. The census of 1890 gave that city 1,099,000; but according to local statistics Chicago has now about 2,000,000 inhabitants. It is a great and big city anyhow, whether it ever eclipses New York, or not. The prospect now is, however, that it must defer that glory for a time, at least as far as population is concerned.

SAFETY FENDERS AND IMPROVED BRAKES ON STREET RAILWAYS.

The increasing frequency of street railway accidents, resulting from the rapid introduction of electric and cable power in place of animal power on our street railways, is arousing the public to the necessity of some action by which the danger from greater speed may be decreased without foregoing the advantages of increased rapid transit possible with mechanical propulsion. But while one who has followed the daily record of killed and maimed in the newspapers must acknowledge the urgency of such action as is being taken in several of our larger cities, the question arises as to whether the precautions demanded are the only ones needed. If we may judge from the press reports, most of these cities have confined their work to urging the use of fenders attached to the front end of the car, like the pilot of a locomotive engine, the object of which is to pick up the person struck, or to push him to one side or carry him along out of danger from the wheels until the car can be stopped. Indeed, at a superficial glance a fender is the most obvious and apparently most logical device for securing safety from collision.

In another column we describe and illustrate a number of fenders of different types. These have all been tested by actual use and may be accepted as representative of the general lines along which the most successful forms of the device have developed. It is not necessary to discuss here the merits or demerits of individual fenders, but the recent agitation in several cities for the compulsory adoption of fenders by the street railway companies requires some comment, especially as their use seems to be generally considered the one necessary measure to prevent further injuries to persons on the track.

An increased liability to collision is the concomitant of the increase of speed which has followed the introduction of mechanical propulsion on street railways. If collisions are to be prevented, it is evident that some means for controlling this greater speed and the momentum of heavier cars must be secured. All that any fender can do is to reduce the danger of death or serious injury from collisions when they occur. Its use cannot affect the frequency of collisions except to increase them by impressing the motorman with a sense of security which makes him less careful to avoid colliding with persons or vehicles crossing the tracks. It may be thought that the danger of colliding with vehicles or other cars is small compared with the danger of colliding with pedestrians, and the danger of killing any one in such collisions still less. This is undoubtedly true, yet we can recall half a dozen collisions with vehicles on the electric lines of a single city within the last three months, two of which at least have resulted in the loss of life. Within the last few weeks the papers have recorded three or four collisions between cars and vehicles or two electric cars, in each of which several persons have been injured. It is clear that fenders are of no value in such collisions as these. As to collisions with persons crossing the tracks, all that any fender can do is to minimize the danger of killing or maiming a person run down by a car. There is no doubt that the better forms of fenders will do efficient service in saving life and should be adopted on street railways. We would say nothing against such improvements; but at this time when fenders are attracting so much attention, it needs to be pointed out that we should not only strive to make collisions less dangerous, but to prevent them altogether, so far as this is possible. To effect this we must look to the brake power and the proper regulation of speed.

With the increase in the speed and weight of street cars which occurred when the electric motor displaced the horse, there has not been a proportionate increase in the braking power, but on the contrary a relative decrease, since the old horse car brake, not much increased in power, is still used almost universally. It is but right to say, however, that the brakes commonly used on cable cars are somewhat better, as they allow of quicker application and are generally more powerful. But here, as with electric cars, the muscle of the driver is the only force for applying the brakes and in sudden emergencies this is only partly available since the driver's attention must first be given to releasing the grip. We have already discussed the inefficiency of street car brakes in our issues of July 11, 1891, and Sept. 21, 1893, and shall not dwell upon it here, but it is toward their improvement that attention must be directed if we would increase the safety of electric and cable cars and make practicable high rates of speed on surface street railways.

The New York State Railroad Commissioners in their last report (Eng. News, Jan. 18, 1894) have realized the importance of this question of better brakes for street cars and recommend its consideration by managers of electric and cable roads. They say:

> During the past year the Board has made examinations as to the movements of street cars in the cities of the State, and is impressed with the benefits which might be derived from the use of some form of power brake by street railway companies. The necessity of quick stops on steam railways, which led to the adoption of the straight air-brake and afterward to the automatic brake, is now being experienced on street railways operated by cable and electric power. Instances are frequent where the reduction of speed in a second of time is necessary to prevent accident, and this can only be secured by some form of air-brake.

Thus far such forms of air-brake as have been designed for street cars have not proved entirely satisfactory, and this has given a plausible and to some extent a valid excuse to street railway

managers for not equipping their cars with them. Yet, where such brakes have been fairly tried in service they have proved their value and demonstrated the possibilities of the system. Mr. J. H. Robertson, Superintendent of the Third Ave. R. R., in New York city, who has experimented quite extensively with one form of air-brake, writes us as follows:

> During the last summer we had four open grip cars with trailers attached, fitted up with the Genett air-brake, and ran them on the 10th Ave. and 125th St. cable lines with good results. We are now fitting up all our cars on that line with the brake, as we expect to use trailers more or less through the summer months. I think they are an improvement over the old plan of having a brakeman on the trail car, and they give the gripman more perfect control of his train.

The Genett air-brake was described in our issue of July 29, 1893. As stated there, the defect in this brake seems to be the lack of any means for regulating the pressure except by throttling the air by the motorman. In fact, it is doubtful if any such effective development of the air-brake can be looked for on street railways as has been made on steam railways for obvious reasons, but we believe the mechanical genius which has brought about the present state of perfection in automatic air-brakes can be confidently depended upon to evolve a brake which will amply provide for the lighter loads and slower speeds of street railways as soon as there is certainty of a demand for such brakes by street railway managers.

It should be noted here, moreover, that the prevention of collisions is not the only reason why more powerful and reliable brakes are needed on street railway lines. As was explained at length in these columns some months ago, electric cars are run over grades which were never thought of when animal traction was the rule, and hardly a week passes but what some case of runaway on a steep grade occurs with more or less serious results.

Second only to the use of power brakes in securing safety from collision is the proper regulation of speed. Comparatively few cities have adequate regulations covering this point, such ordinances as exist usually prescribing simply a maximum limit of speed which it is always difficult and often nearly impossible to enforce, even with the most careful system of inspection. Of course on cable lines the speed of the car (save when coasting down grades) is limited by the speed of the cable, but on electric lines the faithfulness of the motorman in obeying the regulations is the only security, and the temptation to "make time" when late generally overbalances any conscientious scruples he may have on that point. Any one who has taken the trouble to observe knows that in many instances cars are run at an excessive speed, despite regulations.

In his report to the Brooklyn, N. Y., Subway Commission, Prof. G. W. Plympton, M. Am. Soc. C. E., in speaking of the regulation of speed on electric roads, said:

> Regulation of speed can probably be accomplished only by a mechanical governor which will limit the rate of the motor to that required to propel the car at the maximum legal velocity.

It may be questioned in how far such a regulator would be of practical value. What would be a perfectly proper rate of speed for suburban streets would be an excessive rate of speed for thickly crowded streets, and as far as the latter are concerned a regulator adjusted to the greater speed would be of no value at all. Of course a certain value attaches to the use of any form of efficient speed regulator or indicator for street cars, but it must be remembered that high speeds are objectionable only because the cars cannot be stopped quickly enough to prevent collision.

A form of city ordinance which suggests itself and which would be generally applicable to all conditions is to regulate the speed according to the braking power, i. e., to stipulate that the maximum permissible speed shall be such that the car can be stopped within a certain distance with the standard brake in use on the road. This distance might be made different for different parts of the route. The advantage of a speed-limiting ordinance in such a form would be that it would stimulate the street railways to adopt quicker acting and more powerful brakes, since the more efficient the brake, the greater the speed, within certain limits from which a car could be stopped within the specific distance.

LETTERS TO THE EDITOR.

LONG PLATE GIRDER BRIDGES.

Sir: I notice in your issue of Feb. 15 an item in regard to a 182-ft. plate girder swing bridge that is being built for the Washington & Chesapeake Beach R. R. by the Youngstown Bridge Co. This, you say, you believe to be the longest plate girder span ever erected in this country. In 1886 the Chicago, Burlington & Quincy R. R. built at its Aurora shops, from designs made in the office of its Chief Engineer, a plate girder draw-span 189 ft. 9 ins. long. This was erected in the same year at Quincy (Ill.) Bay and forms part of the approach to the bridge across the Mississippi River at that point, an island intervening between the main river and what is known as Quincy Bay. There were built at the same time for this same structure four fixed spans of deck plate girder, 84 ft. 7½ ins. each. These spans replaced the "Bollman" bridges which were put in when the bridge was built in 1868.

Yours truly, L. P. G. B.

Chicago, Feb. 22, 1894.

ERRATA IN "CLEANING AND SEWERAGE OF CITIES."

Sir: Please allow me to call attention to the following errors in "Errata in 'Cleaning and Sewerage of Cities'":

"Page 128, in Fig. 133 a letter 'a,'" etc., should be "Page 132, in Fig. 133," etc.

"Page 165, 12 lines from top," should be "Page 164 12 lines from top."

"Page 170, 5 lines from top," etc., should be "Page 174, 5 lines from top," etc.

"Page 232. Change the captions of Figs. 188 and 189." To what are the captions changed?

Very truly yours, Jos. R. Moreland, C. E.

Olean, N. Y., Feb. 26, 1894.

(The captions of Figs. 188 and 189 are to be changed one for the other. The word "transpose" would have been better than "change."—Ed.)

Sir: Replying to your request for corrections of Baumeister's "Cleaning and Sewerage of Cities," permit me to call your attention to Table II., p. 13, "Maximum Intensity of Rainfall," wherein it gives a precipitation of 16.91 cu. ft. per sec. per acre on June 4, 1871, at Galveston, Tex. This precipitation record, I am informed by Dr. I. M. Cline, Local Forecast Official at Galveston, is unreliable.

Mr. Cline furnished me a precipitation table for the period included between April 19, 1871, and Aug 31, 1892, in connection with a study of the sewerage of Galveston, which I made a little more than a year ago. That table gave the precipitation "June 4, 1871, 4:10 a. m., to 4:16 a. m., 3.95 ins.," amounting to a rate of precipitation of 39½ ins. per hour. The rate was so excessive that I called his attention to it, with the above result. Yours truly, W. Kiersted.

Kansas City, Feb. 28, 1894.

AREA NEEDED FOR SEWAGE DISPOSAL BY IRRIGATION.

Sir: I regret to see that either I or the types have made a serious error in my article on the area needed for sewage disposal by irrigation, page 143, Feb. 15. The "160,000 gallons" in the ninth line of the second paragraph should be 80,000 gallons. The fact was also overlooked that the descent of water through the ground during the day of application would amount to another 30 ins., making the depth of subsoil, of which the voids are made available, 24 ins. instead of 14 ins. These errors, however, offset each other, and the stated capacity of the total space available for absorption (sufficient for 275,000 gallons) is correct.

These changes are important as a matter of accuracy of statement, but, as indicated in the article, the computation of which they form a part is a purely theoretical one, and its factors would depend so entirely on the quality of the soil that it can have no further value than that for which it was intended—to show what the possibilities as to capacity may be under certain conditions. Very truly yours.

Geo. E. Waring, Jr.

Newport, R. I., Feb. 23, 1894.

CELLULOID SCALES.

Sir: Noting the letter about celluloid scales in your issue of March 1, the following may be of interest: I have a flat, all celluloid scale 1½ ins. wide and 1 ft. long, and about as thin as Bristol board. Its flexibility makes it very convenient, but for one defect; for the three years I have had it it has been steadily and uniformly shrinking and is now 1-16 in. short in 1 ft. If gluing celluloid to wood will surely prevent its shrinking, that is good, but celluloid alone will evidently not answer. Yours, Chas. J. Bates.

New York, March 2, 1894.

(We said "gluing," in our note in reply to another correspondent's query, but intended the word to be taken in a general sense. The exact method by which the celluloid is attached to the wood is a trade secret of the manufacturers.—Ed.)

TUNNELING UNDER THE EAST RIVER.

Sir: The experience of the writer while engaged on work in this city tends to confirm the opinion you have expressed in your last issue as to the possible existence of a vein or trap of decomposing or decomposed rock, of a peculiar character, not far from the East River Gas Co.'s tunnel. At the period referred to a decomposed rock of a wet, pasty character was uncovered and may possibly be an outcrop of the vein encountered under the East River. The underlying rock on the east side of Manhattan Island appears to be a combination of mica, pebbly quartz and feldspar (with small garnets intermixed in some localities), from which it is inferred that the soft deposit referred to is a decomposed feldspar. The existence of this material in the line of subaqueous tunnel operations might prove troublesome.

It is possible that veins of this material may be found at other points on Manhattan Island or in its vicinity.

I think that another and similar but drier deposit was uncovered on the east side of the island somewhere between 28th and 34th Sts. These facts seem to warrant your inference of the existence of this peculiar material in and adjacent to this city, and suggests the advisability of thorough exploration before inaugurating costly and important enterprises. A slight change of site might insure safe, economical and rapid prosecution of work and prove highly advantageous in the subsequent work on land by operating along the most desirable routes as indicated by the physical features of the locality. It may be inferred that the location of the East River Gas Co.'s plant at Ravenswood, the position of the public buildings on Blackwell's Island, the Transverse Road through Central Park and the desirability of making the shortest connection with their 36-in. main on 66th St. exerted some influence with the company in the selection of the present site of their tunnel, and of 71st St. as the line of subsequent operations. The physical features of 71st St. and the large water main on one of the avenues would be somewhat disadvantageous to the proper prosecution of the work, the cost of which would also be greater, probably, than if a more desirable route had been selected. It would seem advisable to avoid rock excavation as much as is consistent with proper work, for in some cases rock excavation in city streets is either synonymous with shallow trenches, incompetent or unsatisfactory work, or increased cost; nor are these arguments invalidated by the fact that the work has been executed under contract by the lowest bidder. Respectfully,

Thomas H. Kane.

New York, March 5, 1894.

THE EAST PROVIDENCE STAND-PIPE FAILURE.

Sir: The communication which appears in your issue of March 1, under date of Feb. 17, from Mr. C. H. M. Blake, relating to the cause of the East Providence stand-pipe failure, leads me to call attention to the fact that the cause suggested by Mr. Blake was anticipated and extended in the MS. which I sent to you on Feb. 3. Having been engaged for a considerable period in compiling a record of stand-pipe accidents and failures in which "cause of accident" has received close consideration, the writer had at hand facts which at once suggested what he firmly believes was the true cause of the final failure of the above-mentioned stand-pipe on Jan. 19. The record of accidents above referred to was about completed when this last failure occurred, and a delay of a week or more was necessary in order to give proper consideration to the statements of Mr. Leland, which appeared in Engineering News and "Engineering Record" of Jan. 25 and 27, respectively. The following discussion as to the cause of the East Providence failure was prepared previous to Feb. 1:

> The wide variation in the thickness of the ice found in the ruins indicates that the ice tube which formed during the period of cold weather while communication with the mains was cut off, was eccentric in shape, having a thickness of 18 ins. on the northern side and of only 3 ins. on the southern or southwestern side, where the action of the sun was the greatest. The tube of ice doubtless formed against the interior cylinder surface up to the stationary level of the water, and it would seem that the connection of the ice with the bedplate was water-tight. Assuming such to have been the case and that the action of the sun upon the south or southwest side of the stand-pipe had formed a film or pocket of water between the metal and ice shells upon that side, it is only necessary to have had a freezing temperature in order to subject the stand-pipe to strains probably more severe than may be otherwise possible, unless, perhaps, it be those which are produced by the fall of a large body of ice through a considerable distance. Inasmuch as the latter was impossible under the existing circumstances, the former is here advanced as the most probable explanation of the failure. It may properly be added that according to this theory the pocket, and consequently the initial rupture, would naturally occur on the south or southwest side of the stand-pipe, and that rupture might take place at almost any point in the lower nine-tenths of the height of the ice tube, the strain required to produce rupture growing less, of course, with the decrease in the thickness of the plates. Thus it will be seen that if the initial rupture took place at a point 55 ft. above the base, as state by Mr. Leland, the pocket of confined but unfrozen water probably existed there and the failure originated in a plate having a thickness of ⅝ in. It is furthermore of

importance to observe that the formation of such pockets is probable only when the ice tube extends to a tight connection with the bedplate, which latter condition may rarely, if ever, be found to exist except when the stage of the water remains constant for some time during freezing weather, such for instance as in the case of the Asheville (N. C.) stand-pipe. In proof of the fact that the force generated in the manner above indicated would be sufficient to cause plate fracture, reference may be made to the well known "bomb-shell" experiments or to the various evidences in nature of the powerful action of frost.

Since writing the above discussion extracts from the local meteorological record have been obtained through the courtesy of Mr. J. Herbert Shedd, City Engineer of Providence, R. I. Although the temperature, cloud and wind records for Jan. 19 and for a day or two previous are not distinctly those above assumed, it is not necessary, for that reason alone, to abandon the theory as advanced, for it seems entirely within reason that with steel having the excellent qualities previously exhibited by the plates in the upper portion of the stand-pipe, it would be possible that the expansive force might have been acting intermittently, or perhaps, continuously, through some time, and that on the evening of Jan. 19, when the temperature was at or slightly below freezing, the contractive tendency of the already strained plates, acting with the powerful expansive force of the confined water, caused the initial rupture, probably at the point "A" referred to by Mr. Leland in his last communication in Engineering News of Feb. 22, 75 ft. from the base.

The theory offered by Mr. Blake "that the rupture might have been caused by the sudden expansion of the water in the pipe, in the act of freezing, in the same manner that pitchers are so often broken in cold weather," although suggesting the true cause of the failure is nevertheless deficient if reference is made to the main body of water in the stand-pipe, for the sheet of ice originally formed at the 85-ft. level had been cut loose and was, at the time of failure, floating freely near the 100-ft. level.

It was known by actual observation that with frequent pumpings the ice tube is melted away in its lower portion, so that, as a rule, the pocket which forms by the first melting on the side exposed to the solar heat, has a direct connection near the base with the main body of water. This fact, the writer believes, accounts for the great scarcity of such failures as those of East Providence, R. I., and Asheville, N. C. The latter failure occurred Jan. 22, 1893, during freezing weather, preceded by several clear days, and it is a significant fact that for some time previous the stand-pipe had been used to hold a reserve supply for fire service only, and that an ice tube having walls 7 or 8 ins. thick had been formed from the fixed water level to a water-tight connection with the bedplate.

Yours truly, Wm. D. Pence.

University of Illinois, Champaign, March 3, 1894.

(In justice to Professor Pence and because of the value of his communication, we take pleasure in giving space to the above and in stating that a valuable monograph on stand-pipe accidents and failures, written by him and containing the above quotation, was in our hands prior to the date of Mr. Blake's letter.—Ed.)

EARTH DAMS AND RESERVOIR EMBANKMENTS.*

By Desmond Fitz Gerald, M. Am. Soc. C. E.

Having lately designed two high embankments for the storage of water for the city of Boston, both between 60 and 70 ft. in height, and having devoted some time to the study of the theories and practices connected with their construction, it may perhaps prove of some value to some one if I give a condensed historical review of the evolution of earth dams and also a brief description of the dams above alluded to.

There have been many failures of reservoir embankments in England, and as the experience of that country is covered by many generations, where ours extends only a few years into the past, let us take a glance first at English practice. It may be said, I think with truth, that very few embankments of proper slopes have ever given way under the pressure of water. They have generally failed: First, from insufficient wasteway, and, second, from the method of drawing out the water through pipes, culverts or tunnels. The question of the proper design of spillways does not enter into our inquiry, as this subject has been fully treated elsewhere and the conditions for proper design are well understood by all hydraulic and water-works engineers. I will only say, in passing, that many failures of banks have been ascribed to defective outlets which have really been due to water overtopping the dam.

Assuming then that a dam has abundant length of overflow, it is safe to say that the weak point is in the outlet. In the embankments first built in England the pipes were laid through the artificial banks and the valves placed on the outside. Many failures occurred from the settling and fracture of the pipes under the weight of the embankments; and as there was no control to the water from the inside, of course nothing could save the dam. This led to building culverts excavated in the hard ground under the embankments. In these culverts pipes were placed, with stop or cut-off walls near the inner slopes. The valves were generally placed on the inside, either directly in line with the slope, or oftener in valve towers, of cast iron or masonry, connected with the tops of the dams by bridges.

The culverts have given way in most instances by settling under the weight of the embankment; also by crossing the puddle trench or core of the dam without special precautions; and by having puddle placed around them. Puddle is a dangerous material to use where the heads are great. It is of course comparatively safe in the heart of an embankment, but when placed around pipes or in a position where it can escape gradually under a small leak, it is to be used only with the greatest care.

The puddle trenches in most English dams are carried to great depths. Where the culverts were built across them the clay was very apt to settle and break the masonry. This led to constructing slip joints, which were clumsy contrivances and seldom successful. Afterward it was found best to begin at the bottom of the puddle trench with masonry foundation and carry it up for the culvert to rest on. All these precautions did not insure success. In the first place, the sinking of the trench for the core wall and the pumping of the fine materials out of the soil on each side of the center line of the dam, are apt to disturb the ground and leave a poor foundation for the culvert. Several of the most eminent engineers in England have argued that the only safe way to take a pipe out from a reservoir is to drift a tunnel through the natural ground around the ends of the embankment, connected with a valve tower in the reservoir. The water can be taken either directly into the tunnel or led out in pipes. Mr. A. R. Binnie, in a discussion before the Institute of Civil Engineers, says:

> By a tunnel outlet, he meant an outlet driven in the solid rock or shale, below the surface by mining either round the ends of the reservoir, as in the case of the Stubden reservoir, or passing deep into the solid rock or shale and below the bottom of the puddle trench, as at Leeming and Leeshaw. By a culvert outlet he meant any brick or masonry work which was built under the embankment or in cutting which was afterward filled in and covered by the embankment.

This engineer cites the failure of the Leeming reservoir as a case where the culvert was fractured at the puddle trench, although a slip joint had been used. The Leeshaw culvert, with no slip joint, was fractured under only 10 ft. of embankment. The failure of the Vartry reservoir, in Dublin, in June, 1867, was due to water finding its way between the rock and the puddle which surrounded the outlet culvert.

Mr. Bateman, who had built more than a hundred reservoirs, great and small, said in the same discussion:*

> But as to the proper mode of discharging water from reservoirs I am as uncertain as I was 40 years ago. I have long ago abandoned puddle; in difficult circumstances I have no confidence in clay.

A. Jervis, another English engineer, contributing to the same discussion, thought the building of tunnels might be carried too far. The stratification might not be favorable for a tunnel. He suggested that a culvert built in an open trench along the side of the valley might be best, especially where the intersection with the puddle trench was in rock. R. Hassard preferred, where the ground was good, a culvert in deep trench on side of valley entirely under the puddle trench.

The failure of the Dale Dyke reservoir connected with the Sheffield water-works is frequently alluded to in English publications. This embankment was 102 ft. in height, and it held 96 ft. of water. It was poorly built and the pipes were carried through in a trench in the rock and surrounded with puddle. The valves were on the outside. Opinions differ as to the cause of the breach in the dam, which resulted in the loss of 250 lives.

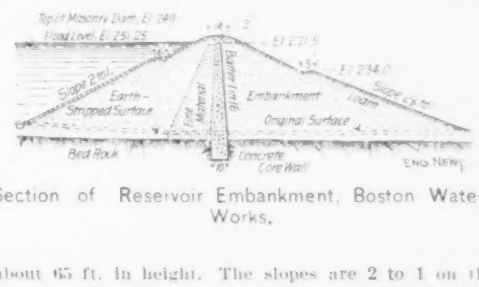
The almost universal practice in England is to build the inside slopes 3 to 1 and the outside slopes 2 to 1, and from observations of my own, particularly on dam No. 4 of the Boston water-works, I am inclined to believe that for high and important dams this is a good rule. It is almost needless to add that all pipes or culverts should be well provided with flanges and rings of masonry to prevent the water from creeping along the horizontal lines.

Allusion is frequently made to the old bunds in India, and a word or two about these old dams may not be out of place. One of these forming the Cummins tank, consisted of an earth bank 102 ft. high, with 90 ft. of water. The slope on the water side is 3 to 1 and on the outside ½ to 1 at top and 1 to 1 on the bottom, revetted. These old dams, which have stood for centuries, were made by dumping small amounts of earth from baskets, and they were consolidated in some cases by elephants treading upon the earth. No core wall was used. It has been stated that India is full of irrigation reservoirs which have failed by water following the outlet sluices.

According to Humbert the width of an earth dam on top cannot well be less than 6 to 8 ft., and it is frequently 12 to 20 ft.

I believe Mr. Rawlinson's rule was 30 ft. wide at the flood water level, and this gentleman's rule for puddle cores was that the thickness should nowhere be less than one-third the head of water.

Having given a summary of English practice, I will now state the practice on the Boston water-works and some reasons therefor. The illustration accompanying this discussion shows a section of an embankment



Section of Reservoir Embankment, Boston Water-Works.

about 65 ft. in height. The slopes are 2 to 1 on the inside, with a berm 6 ft. wide about 8 ft. below the flood level. These slopes are paved on a broken stone foundation. The slopes on the outside are 2 to 1 down to the berm, which is 20 ft. below the top, and 2½ to 1 below the berm. These slopes are covered with at least 2 ft. of loam. The site is stripped of all soil containing organic matter, and after the core wall has been started the bank is built up in 4-in. layers, watered slightly and rolled. The core wall is of concrete, plastered with Portland cement on the water side and with an occasional buttress on that side to stop the creeping of water lengthwise of the dam. The core wall is carried to the rock 40 ft. in places in the case of dam No. 6, and is to be in a comparatively shallow trench in the case of Dam 5, where the rock comes nearly to the surface.

Adjoining the core wall on the upstream side is placed selected fine and clayey material. The rest of the embankment is of gravel or whatever material may be convenient. The slopes, however, both inside and outside, should be of loose gravel to prevent the slipping on the water side when the reservoir is rapidly drawn down and to allow any leakage to pass freely away on the lower slope. This is an important point too often neglected. Where the material on the slope is of a clayey nature a slide is apt to take place, sometimes taking the paving or riprap down with it to the bottom of the reservoir.

In considering the stability of this kind of an embankment, we must assume that the full head of the reservoir is carried to the core wall, which is intended to be watertight. The material on the downstream side of the wall must then, by its weight, withstand the pressure of the water, besides a saturated prism of earth on the upper half. The factor of safety is about two, in the case before us, so that it would not have been wise to make the slopes any steeper on the downstream side.

There are several ways of solving the problem of building a high dam of earthwork. If there is to be no core wall, then perhaps it will be safer to make a gigantic filter of the section, as has already been done in the case of some of the canal banks in India. The inner slope is made as tight as possible, next fine sand is placed, giving way to coarser and coarser material, until the outer slope is met, which is composed of a mass of rubblestone. The object of this arrangement is to provide for the safe passage of any leakage from the inside to the outside of the embankment without carrying with it any of the material of which the bank may be composed. In the case of an important dam holding back a large amount of water, which might cause great damage if suddenly released, it has always seemed to me that no chances should be taken. If the puddle is placed on the inner slope it will take more of it to accomplish the same result than if placed in the center of the dam on account of the longer line which it follows. Again, a large sheet of puddle is more exposed to changes of condition and it is more liable to crack and leak, and certainly it is more liable to change its position by slipping.

* From a discussion before the New England Water-Works Association. The discussion was opened by Mr. Lucian A. Taylor, M. Am. Soc. C. E. A part of Mr. Taylor's paper was abstracted in Eng. News, Jan. 18, 1894, under "Society Proceedings," and the balance in our issue of Jan. 25 under the title "Repairing a Break in the Lynde Brook Reservoir Embankment." The discussion given herein will be published in full in the Journal of the New England Water-Works Association. See Eng. News, Oct. 5 and 26, 1893, for a discussion of this subject before the Boston Society of Civil Engineers by Messrs. Desmond Fitz Gerald, A. Fteley and others.

* Vol. LIX., Proc. M. Inst. C. E.

One of the advantages of a masonry core wall is that no animal can burrow through it, and it is more difficult for any small leak to grow larger than it is in the case of clay puddle. In the section given in the accompanying cut it will be noticed that curved surfaces have been given to many of the exterior angles of the section. They are more natural and easier to maintain than sharp corners. The berm, halfway down the exterior slope, is introduced for drainage purposes, while the sod is forming. A gutter is formed in the berm, with slight slopes lengthwise of the dam leading to sod gutters running down the bank to keep the loam from being washed away by heavy storms.

In the case of Dam 6, the lower outlet pipe, 48 ins. in diameter, is laid in masonry on a rock foundation on the side of the valley. The core wall is carried over and around the masonry and besides these precautions, frequent cut-off walls have been introduced along the line of the pipe. Another outlet pipe at a higher elevation is placed in a tunnel on a rock foundation at the other side of the valley. This pipe is placed in a tunnel because it is to be under pressure. The valve towers or pits are of masonry and located just inside of the core wall, which is continuous behind them.

In my own experience I have seen reservoir embankments fail which have never been alluded to in the public prints. It has occurred to me that some one anxious for a subject for a thesis could not do better than to look up and describe accurately the conditions attending the failure of so many of our reservoir embankments, especially the details connected with the smaller reservoirs which have given way and which have never attracted public attention because they have been unaccompanied by loss of life or other serious damage.

I cannot agree with Mr. Taylor's statement that the tightest dams are those of earth. The tightest dams that I know of under great pressure have been carefully built stone dams. In regard to what Mr. Tidd has stated about the dryness or wetness of materials I wish to say that it must be evident to all that there must be no lumps in the puddle or else it has not been thoroughly worked, but there is hardly any material which will absorb larger percentages of water than clay. If there is any chance for this water to drain off afterward, immense cracks will result. The most satisfactory, solid and watertight puddle that we have used at Dam 6 has been that which contained the least water, but it must be made perfectly homogeneous and thoroughly worked. In making a solid bank which shall be free from sediment, more depends upon the rolling and ramming than upon the watering. We have built high embankments on the Boston Water-Works which have not settled more than $\frac{1}{2}$ in. in 50 ft.

In building reservoir embankments an engineer must be guided by the local conditions and the resources at command. His design must be largely affected by the nature of the materials. There are certain general principles, however, which must be observed and which will be applied by an engineer of skill, judgment and experience to whatever design he may adopt. It is in the application of these principles that the services of the professional man become valuable, and it is from lack of them that there have been so many failures in the structures we have been describing.

THE GALVESTON COUNTY (TEX.) HIGHWAY BRIDGE.

The bridge connecting Galveston, Tex., on Galveston Island with the mainland across West Galveston Bay, which we illustrate in the accompanying cuts, is probably the longest iron or steel highway bridge ever constructed; the only other bridge of greater length ever built, as far as we now recall, being the railway trestle across Lake Pontchartrain, in Louisiana. The following brief description of the structure has been sent us by Mr. H. C. Ripley, of Galveston, Tex., the engineer of the work for the county of Galveston, at the expense of which the bridge was built:

The contract for the highway bridge across West Galveston Bay was let to Mr. A. J. Tullock, proprietor of the Missouri Valley Bridge & Iron Works, of Leavenworth, Kan., for $183,500. Work was begun in November, 1892, and the bridge was completed in October, 1893. Some extension of the trestle and the extras allowed brought the total cost up to $191,986. No account having been kept of the cost of the different classes of work, any statement of cost must be regarded in the nature of an estimate based upon the cost of the structure as a whole.

The bridge consists of 80 fixed spans and one draw span of steel, resting upon 92 concrete piers, making a total length of metal structure of 7,432.5 ft. The 3,877 ft. of pile trestle approach added to the steel structure gives a total length for the bridge of 11,309.5 ft. The piers rest upon a pile foundation with or without grillage, which was constructed in the following manner:

An iron caisson somewhat larger than the base of the pier was first sunk at the site of the pier and the material of the bottom dredged out to a depth of two or more feet, and if hard bottom was found at that depth, no grillage was used. The piles were driven to a firm bearing at a uniform level of about 2 ft. below the bottom of the bay, except the center row, which was allowed to project 5 ft. above the rest and extend into the mass of concrete composing the pier. Where the nature of the bottom was such that too much dredging was required to reach solid bottom a grillage was used which was composed of timbers 12 ins. thick, placed on top of the piles, which in this case were all driven to a uniform level. The number of piles used for the ordinary pier varied from 17 to 24. The pivot pier, which supports the swing span, rests upon 63 piles.

After driving the piles the mold for the pier was placed in position and filled with concrete. This mold was in two sections, the first section extending just above the water surface and the second section to the top of the pier. The second section was not placed until the first section of the mold was fastened to the grillage by means of wood screws and could be released when the concrete had become set and hardened sufficiently to permit it.

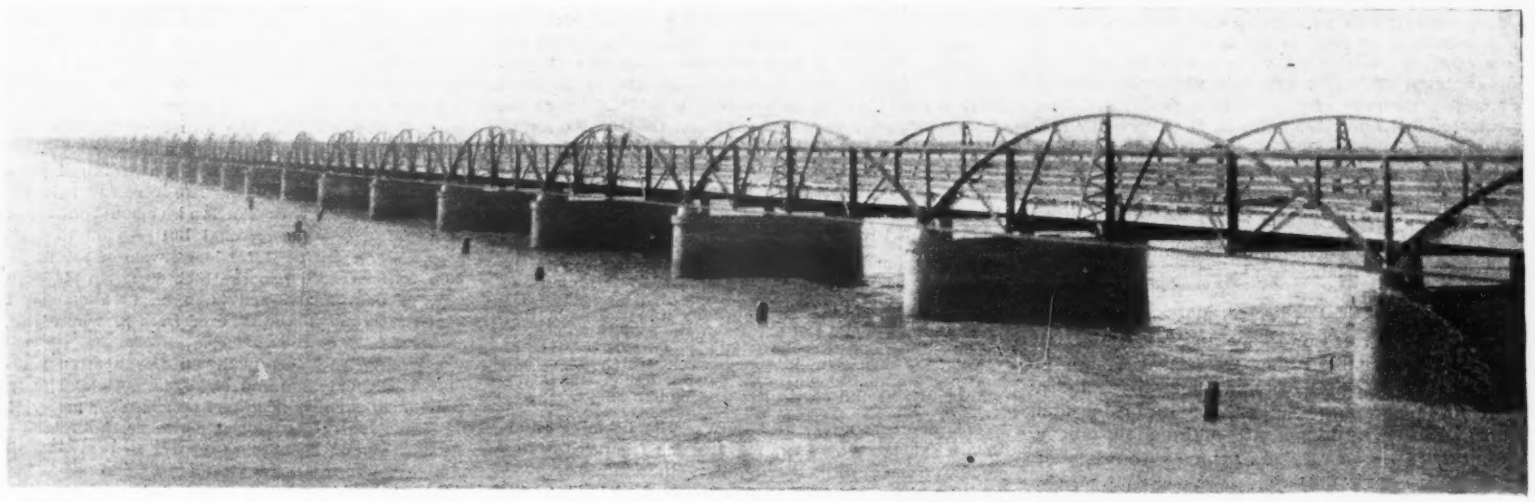
Steel spans were floated into position on a barge and fixed by means of anchor bolts previously imbedded in the concrete of the pier. The draw span was erected in position. The trestle where exposed to the water was built of creosoted piling. Where it was not so exposed cedar piling was used. The concrete was made of Gillingham Portland cement, good, sharp sand and a good quality of broken sandstone in the proportions of 1 of cement, 3 of sand and 5 of broken stone.

The cost of the work in detail was as follows:

Cedar pile approach.....	$6.00 per lin. ft.
Creosoted pile approach	6.75 per lin. ft.
Steel spans, including wood floor....	13.00 per lin. ft.
Concrete piers, including foundation.	15.00 per cu. yd.

Some further details not given by Mr. Ripley have been obtained from a description of the bridge in the Dallas, Tex., "Morning News," and from Mr. A. J. Tullock, the contractor. The general design of the trusses is shown in the illustrations. They are of the bowstring type, and are divided into four 20-ft. panels each. The top and bottom chords are made up of a pair of angles riveted together to form a T-section and the web members are attached to them by means of gusset plates. The material is all mild steel. The floor beams are I-sections built of plates and angles and upon them are placed the wooden stringers to which the plank floor is spiked. The trusses are 18 ft. apart and are supported upright by outside brackets riveted to the center floor beam, and also, of course, by the riveted connections of the floor beams to the verticals.

The chief interest of this bridge lies, of course, in its great length and the extremely low cost. If we may accept the figures given by our correspondent as correct, the cost of each 80-ft. span, leaving the extra cost of the swing span out of consideration, was $1,040. The steel work is unquestionably light, but the traffic will be light also, and the alternative presented appears to have been to have a fairly efficient, light bridge for the traffic, or to have no bridge at all. Like many other structures in the newer sections of the country, it had to be built according to "what the traffic would bear."



THE GALVESTON BAY BRIDGE, THE LONGEST HIGHWAY BRIDGE IN THE WORLD.

THE SEWERAGE SYSTEM OF OBERLIN, O.*

By W. B. Gerrish, City Engineer.

Oberlin is exclusively a college town, has a population of about 4,400, besides 1,200 to 1,500 students, and owns its water-works. The ground is very level and the soil an impervious clay. A small stream, which is the only available outlet for a sewerage system, flows through the town, and during the summer months runs dry except for the surplus from the water supply system. In 1891 Mr. Gerrish made a topographical map of the town and valley, and later Mr. H. F. Dunham, M. Am. Soc. C. E., reported on sewers, recommending a modified combined system. Afterward Col. Geo. E. Waring, Jr., M. Inst. C. E., recommended the separate system, which was finally adopted for the following reasons:

(1) The sewage, during the summer months at least, must be purified; (2) the village will not be so large for many generations that the surface water cannot be provided for as now, by ditches and a few storm-water drains; (3) the poverty of the village, the tax duplicate being only about $1,250,000; (4) the village being all residence property, with no elevators or manufactories, the amount of sewage will be small.

In the spring of 1892 $12,000 of bonds were voted for a trunk sewer and sewage farm, and the college contributed $1,500, its property not being taxable. The

* Abstract from a paper read before the Ohio Society of Surveyors and Civil Engineers at its meeting at Cleveland, Jan. 16 to 19, 1894.

trunk sewer follows the valley of Plum Creek and one of its branches, and includes 1,360 ft. of 8-in. pipe with a .36 grade, 790 ft. of 10-in, with a .22 grade and 8,650 ft. of 18-in. pipe with a .13 grade. The amount paid the contractor was $8,160. Only about 700 ft. of the trunk sewer was in streets and the balance passed through uneven ground with from 18-ft. cuts to 5-ft. fills.

The creek crossing just before reaching the disposal field was effected by a length of pipe on each of two piers, 2½ ft. sq., and inserting one length between. The pipe was wrapped with haircloth and boxed. The cost was much less than for an inverted siphon and the results more satisfactory.

Out of the 8,650 ft. of trunk sewer 1,300 ft., ranging in lengths of 28 ft. to 500 ft., was found broken upon attempting to pass a ball through it. The pipe used was 1¼-in. vitrified fire clay, carefully laid with jute gasket and imported cement joints and with good bell holes in the trench. No tamping or flushing was done. The breaks occurred under varying conditions of material and trench depth, and no explanation can be offered. In relaying, shale clay pipe was used and great care taken to tamp the earth about the pipe, but in a month 150 ft of the new pipe broke in the same manner, that is four straight cracks lengthwise of the pipe, at the top bottom and each side.*

The district sewers have a total length of 30,500 ft. and comprise 25,000 ft. of 6-in. pipe on a 0.4 or 0.6 grade, and 5,500 ft. of 8-in. pipe on a 0.4 grade. There are 23 Rhodes-Williams flush tanks and 4, 6 and 8-in. second grade vitrified pipe. Subsoil drains were laid beside all district sewers with a sealed T in manholes. Y's were put in 50 ft. apart. The average cut of the district sewers was 8.2 ft. and the cost, exclusive of engineering, was about $17,700 or $3,000 per mile.

When cellars are to be drained a 3-in. pipe, with cement joints, is laid to the subsoil drain and connected with it by means of broken stone. In the middle of January about 80 connections, including the college dormitories, had been made with the sewers and about 40,000 gallons of sewage per day was passing through the sewers.

*Since this article was put in type a letter has been received from Mr. Gerrish stating that the cement used for the pipe joints was German Portland, 1 to 1. Professor Newberry, of Sandusky, has suggested that the breaking of the tile may have been caused by the presence of free lime in the cement used causing it to swell and burst the pipe hubs.

THE ELECTRIC STATION OF THE CITIZENS' LIGHT & POWER CO., ROCHESTER, N. Y.**

The consolidation of three gas companies and of three electric companies at Rochester, N. Y., into one organization, known as the Rochester Gas & Electric Co., was effected in 1892. After this consolidation some of the stockholders in the different companies organized an independent company, whose plant was designed and constructed by the writer, and is in operation, supplying electricity for light and power. The equipment is of the latest and most improved machinery under the Westinghouse system. The Genesee River runs nearly centrally through the city, and has a fall within the city limits of about 257 ft., in a succession of three falls and rapids. The water is used four times over before it reaches the level of Lake Ontario. The flow since the country has been cleared of timber is much more irregular than formerly, and measures are now being taken to store the water in times of excess of flow by damming it back in the ravine to the south of Mount Morris. The state of New York has the first right in the water of the Genesee for feeding the Erie Canal, and in times of drought the quantity reaching the city is only 4,000 cu. ft. per minute and becomes practicallly useless for the many industries dependent upon it. By impounding the water it is contemplated that a constant power of 30,000 HP. per day may be realized. The fact of water storage in the near future being a possibility was considered by the writer in designing the power station, so that advantage may be taken of it without unnecessary change or expense.

The site of the power station is on Brown's Race, at the foot of Factory St., and work was begun Nov. 28, 1892. As the discharge from a main sewer was continuous and had to be maintained while the work was going on, the first step was to direct the sewage water into a pond near by, by a wooden trough. A cofferdam was placed at the river end to shut off the river water. The water was kept down by steam pumps, so that the rock at the lower end was bared, and from this the masonry of the side walls of tail race was commenced and carried up to 6 ft. above low water mark. An arch of 7½ ft. internal radius was thrown across the top, and the rock in the center was excavated 2 ft. below the water mark. This form of construction was carried on for 165 ft. from the river face of the tail race, and was done in open cut, the old sewer being removed as work progressed. At this point the arch was made semicircular, with internal radius of 6½ ft. so as to better support the weight of the steam boilers that were to be placed directly over it. The circular form was carried 95 ft., making the race proper 260 ft. long. At this point the wheel pit commenced. The pit is 64 ft. long and on the wheel floor 14 ft. in the clear. The wheels are supported on double 16-in. I-beams, resting in the recesses in the rock at the end. The pit is lined with 12 ins. of brickwork, and the wheel floor is laid with 2-in. planks and upon this at right angles to the planks is laid 1½-in. planed and matched hard maple flooring, with a layer of asbestos flooring paper between the two. This was done to cut off any odor arising from the sewer.

All the masonry was laid in Portland cement. The work was prosecuted continuously, excepting Sundays, during the winter of 1892-93, the temperature being sometimes — 6° F. All the mortar was salted, to prevent freezing. The foundations were all upon the rock, with the exception of one short space. The tail race, wheel pit and foundation of boiler house were completed, and the sewage turned into the wheel pit on March 8, 1893. On March 16 the brickwork of buildings and chimney was commenced. The walls of the boiler house and chimney were laid in quick-lime mortar, but all other work in cement mortar. In laying the wall, an inside and outside course of the wall was laid two bricks high, the center was then filled with grout, and the previously wetted bricks placed in it. Headers were introduced every seven courses, and alternated on the inside and outside of the walls.

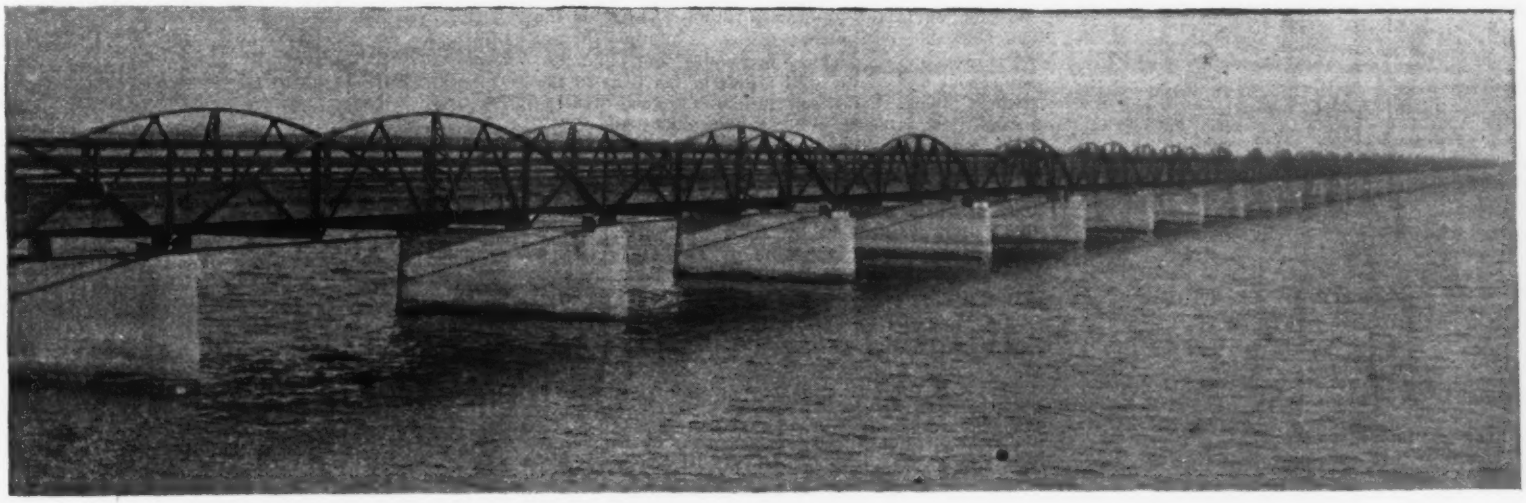
The walls of the main building are 39 ft. high from foundation to eaves. The power room is 24 ft. high and line shaft-room 11 ft. high. Up to this point the walls are 2 ft. thick. At the floor of the dynamo room the floor is reduced to 20 ins. thick and reinforced on the inside with 4-in. pilasters 20 ins. wide, 10 ft. 4 ins. apart on centers. At 17 ft. above the floor the bricks are corbeled out, joining the pilaster heads and forming the bearings for 8 × 8-in. white oak stringers, bolted through the walls, which are to carry an overhead traveling crane. The buildings are covered with steel-trussed roofs, having a rise of 13 ft. at the center. The span of dynamo room is 50 ft., and of the boiler room 48 ft. Each roof has ventilators for light and air. The chimney foundations are on the rock, 14 × 14 ft. square at the base, and 125 ft. high, with a straight flue 8 × 8 ft.

On Sunday, May 7, a heavy freshet was running in the river, and the man in charge of the inlet gate allowed such a volume of water to enter that it overflowed the old race wall at the company's property, and filled a pocket between the rock and the wall, with pressure enough to overturn about 50 ft. of the wall, actually tearing out the rock, which was still clinging to the brickwork at the bottom. The old race wall was very defective, and was entirely replaced. It was necessary to put in a cofferdam while the wall was built and the head-gates put in place. As the rock was irregular, flour sacks partly filled with dry cement mortar was resorted to, to fill the gaps under sheet piling, a layer of bags being placed at the bottom and tamped down so as to pack closely. The cement absorbed the water and set solidly, filling every crevice. The interior was filled with 18 ins. of clay puddle, also rammed down. To keep the dam from slipping, holes were drilled in the rock about 6 ft. apart, and 1½-in. round iron pins dropped into them. Stringers were used, to which the sheet piling was fastened, the first course being 1½ ins. thick and another course of 1 in. was fastened over to batten the joints.

The power room is 50 ft. wide by 64 ft. long, and contains the wheel-pit floor already mentioned, leaving the engine floor 36 ft. wide, with space enough to place four horizontal engines, each of 500 HP. The water wheels are twin, Poole-Leffel, central discharge turbines, 23 ins. in diameter, and develop 500 HP. when run at a speed of 500 revolutions per minute under a head of 92 ft. 6 ins., with a discharge of 3,800 cu. ft. of water per minute. Power is transmitted from the wheel shaft by a rope-wheel 4 ft. in diameter, keyed on the shaft, and grooved for fifteen 1¼ in. manila "stevedore" ropes. These ropes run to the rope-wheel on the line shaft above. This wheel is grooved for sixteen 1¼-in. ropes. The rope being endless, the idler strand is passed over a 5-ft. single grooved wheel, placed in a movable frame, which maintains by its weight a constant tension on all the ropes. The speed of the line shafts is 350 revolutions per minute, and the rope travel is 7,037 ft. per minute. The flume is made with steel plates, and its weight is 31 tons, all coated with two coats of asphalt paint inside and out.

In the power room one horizontal Woodbury compounding, condensing, slide valve engine, with extra heavy bed-plate, is placed. This engine is rated at 500 HP., and is guaranteed to produce a horse-power on an evaporation of 20 lbs. per hour. The crank shaft is a steel forging in one piece, with journals 11½ ins. in diameter and 20 ins long. The arrangement of the rope driving wheel is essentially the same as that for the water wheel, and the speed of the rope is 5,500 ft. per minute. The boiler house is designed for ten 200 HP. boilers, five of which are now in place. The boilers are horizontal tubular, set in brickwork, with the longitudinal seams placed above reach of fire. The boilers are intended for a pressure of 110 lbs., and were proved with a hot water pressure of 180 lbs. The plates and heads are of homogeneous flange steel, with guaranteed tensile strength of 55,000 to 62,000 lbs. per sq. in., and limit of elasticity of 35,000 to 40,000 lbs.

The shafts are all of hammered iron 5 ins diameter, with heavy floor pedestals and fitted with self-adjusting ring-oiled babbit lined bearing. The rope-wheels are placed on heavy cast iron quills furnished with Hill friction clutches of 500 HP. capacity. The pulleys and belts on any line shaft can be operated from any water-wheel or engine by means of jaw clutches.



H. C. Ripley, Chief Engineer; A. J. Tullock, Missouri Valley Bridge & Iron Works, Contractor.

**Abstract of a paper, by Robert Cartwright, presented at the meeting of the American Society of Civil Engineers, March 7.

THE LAREDO WATER TOWER.

By Edward Flad, M. Am. Soc. C. E.

The water tower shown in the accompanying illustrations was built after plans and specifications by the writer for the Laredo Water Co., at Laredo, Tex. The primary object in building the tower was to obtain sufficient storage of water to permit the stopping of the pumps and the banking of the furnace fires during the night hours, the saving in operating expenses attained thereby being more than sufficient to pay the interest on the cost of the tower. The use of the tower also insures a better fire protection. The maximum daily consumption of the city of Laredo is 750,000 gallons; average daily, 353,000 gallons; maximum hourly, 50,000 gallons; and minimum hourly, 4,000 gallons. The capacity of the tank is 85,000 gallons. The tank is 20 ft. in diameter, 40 ft. high, and rests upon supports 85 ft. 2 ins. high, the top of the tank being 120 ft. above the foundation.

The tank is provided with a spherical bottom, as shown in the view, Fig. 1, and the elevation and details, Fig. 2, having a radius of 11 ft. The sides of the tank are extended 15 ins. below the point where the bottom connects with the sides and are provided with angle irons, forming a circular plate

Fig. 1. View of Water Tower, Loredo, Tex.

girder which rests upon 12 points of support. These 12 points of support are obtained by the four main columns upon which the structure rests and eight branch columns, connected to and branching from the main columns at a point 10 ft. 2 ins. below the top of the main columns.

The foundation consists of four concrete piers resting upon the natural rock. On account of the difficulty of obtaining cut stone in this section, the cap stones were also made of concrete. The piers were extended to a depth of 13 ft. in place of 9 ft., as originally designed, and are 13 ft. square at the base.

The structure is built of steel throughout, the tank of "soft steel" between 55,000 and 62,000 lbs. tensile strength and the supports of "mild steel" between 60,000 and 68,000 lbs. tensile strength. The roof is made of wood and is covered with tin, as shown in Fig. 3. The inlet pipe is provided with a stuffing box, as shown, so as to allow for settlement of the tower. The tank complete weighs 13,800 lbs. and the supports 75,900 lbs.

The columns supporting the tank were erected by means of an 8×8-in. gin-pole strapped to the back of the column next below with two iron collars. No scaffolding whatever was used in the erection of the columns. A platform resting on the upper tier of horizontal struts was used in constructing the bottom of the tank, and two light angle iron cages swung on the outside of the tank, in addition to a light scaffolding on the inside, were used in building up the sides. The cost of the structure was as follows:

Tower and tank complete, including inlet pipe and ladder, but excepting roof and balcony	$6,710	
Roof	210	
Balcony	440	
		$7,360
Foundations, including anchor bolts		911
Total cost		$8,271

The tank was filled for the first time on Dec. 15, 1893, and has been in continual use from that time to date (March 2). I believe it is the first tower built with the combination of a spherical bottom and branching columns. The Koken Iron Works were the contractors for the work.

An ordinary plain stand-pipe 20 ft. in diameter and 120 ft. high would weigh at least 160,000 lbs., and estimating the cost at 6 cts. per lb. erected (freight to Laredo being about 1 ct. per lb.), we have $9,600. The foundation would cost at least $1,500, making a total estimated cost of $11,100, as against $7,621 for the equivalent structure as erected, omitting the cost of the roof and balcony. In other words, the cost was some $3,500 less than the estimated cost of an ordinary stand-pipe having the same effective capacity and the appearance is certainly less unattractive, to say the last.*

The "culm filling" system of mining is being urged for adoption in the anthracite regions instead of the old "chamber and pillar" system at present in use. As is well known, under the chamber and pillar system, about 60% of the coal is left in the mine in the form of pillars. Sometimes the mine is gone over the second time, and by robbing the pillars some 25% more is secured. The method of working is more or less dangerous and frequently causes disastrous settlements of the surface over the mine. By the "long-wall withdrawing" system, the roof is supported as the coal is worked out by filling the workings with culm, slate and debris from the breakers. It is claimed that by this plan 95% of the coal can be taken out in practically one operation, and with much greater safety than is possible with the ordinary system of working.

CONSTRUCTION NEWS.

(Readers are invited to contribute items concerning new construction of interest to engineers or contractors for insertion in these columns. Those using these pages for information are informed that announcements of calls for proposals are inserted but once, and are not repeated from week to week.)

RAILWAYS.

East of Chicago—Existing Roads.

BOSTON & MAINE.—This company is reported as taking steps to elevate its tracks through the city of Lynn, Mass.

DETROIT, BAY CITY & ALPENA.—It is reported that work will be commenced early in the spring upon an extension of this railway to Cheboygan, Mich.

FLINT & PERE MARQUETTE.—This company is constructing a 10-mile line north from Baldwin, Lake county, Mich. to a tract of pine, which will be hauled out and to the mills at Ludington, according to reports.

NEW YORK CENTRAL & HUDSON RIVER.—J. M. Toucey, Gen. Man., was at Rochester, N. Y., last week to examine the plans of J. Y. McClintock, Cy. Engr., for abolishing the grade crossing on University Ave. A tunnel would cost about $200,000 or a bridge about $136,000.

PENNSYLVANIA.—The Elkton, Massy's & Middletown R. R. Co. has elected the following officers: Pres., Jacob Tome, Port Deposit, Md.; Vice-Pres., Samuel Rea, Philadelphia; Secy. and Treas., Wm. F. Schwarz, Philadelphia. The capital stock of $250,000 has all been subscribed for and the construction of the road is to be commenced within 90 days, as stated last week.

Projects and Surveys.

CHAZY.—This company has been granted permission to construct a railway 1½ miles in length to connect the works of the Chazy Marble Line Co., Chazy, N. Y., with the Delaware & Hudson.

EDDYVILLE & HICKORY.—Incorporated in New York to build a steam railway 3¾ miles in length from the Newark & Rosendale Lime & Cement Co.'s wharf property near Rondout Creek in the town of Ulster to the Lawrence Cement Co.'s office at Hickory Hush in the town of Rosendale; capital stock, $40,000.

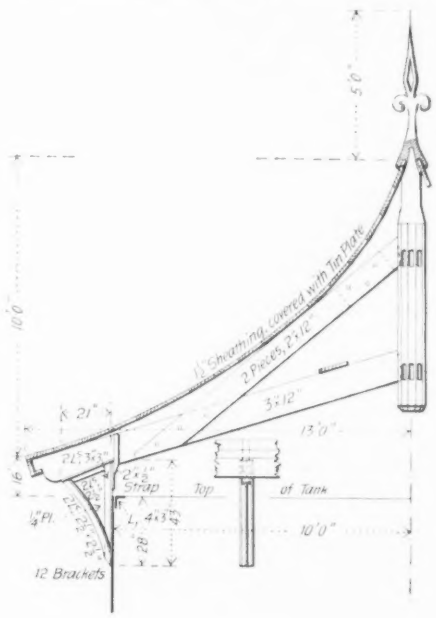
* A design for a spherical bottomed tank, by Messrs. Johnson & Flad, St. Louis, but without the branching columns, was presented in our issue of Aug. 15, 1891. In our issue of Oct. 10, 1891, a large elevated tank, with a spherical bottom, known as the Norton tower of the Liverpool water-works, was illustrated and described in Engineering News. The tank is 82 ft. in diameter and 30 ft. deep at the center, the spherical portion being 15 ft. 7 ins. deep, and the tank being supported at its outer edge by a masonry tower. In Engineering News of March 16, 1893, there appeared a design by Mr. Freeman C. Coffin for an elevated tank with a conical bottom. A pipe based on this general design has since been built at Fairhaven, Mass.

MAINE.—Efforts are being made at Augusta and Rockland, Me., to secure the construction of a railway from Augusta to connect with the Georges Valley road at Union.

Southern—Existing Roads.

KNOXVILLE, CUMBERLAND GAP & LOUISVILLE.—Clarence Carey, receiver of this company, is reported as interested in a scheme to give Middleboro, Ky., a seaboard outlet at Port Royal, S. C.

NORFOLK & WESTERN.—A press report from Atlanta, Ga., states as follows: The report comes straight from authority that cannot be questioned that the Atlanta & Florida and the Marietta & North Georgia will be joined to form a north and south trunk line with Atlanta the central point. There are two surveying parties already getting estimates on the cost of building a line from Marietta to Atlanta to join these roads, and they have been placed in the field by capitalists who have determined upon such a plan, and who are only waiting for the sale of the Marietta & North Georgia to finish up the scheme. The Norfolk & Western has long been seeking an outlet to the Southern coast through Atlanta. This system will build a line from Norton, which is its junction point with the Louisville & Nashville, to Knoxville, where it will connect with the Marietta & North Georgia, which is to be sold



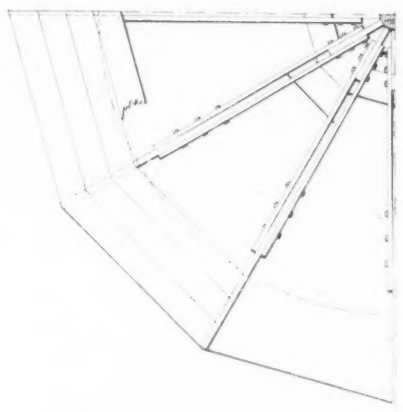


Fig. 3. Details of Water Tower Roof, Loredo, Tex.

March 3. It is the purpose of the Norfolk & Western to buy it up and form the line to the Southern coast contemplated in the plan to join it with the Atlanta & Florida, which can also be bought at low cost.

SAVANNAH & ATLANTIC.—Mayor McDonough, of Macon, Ga., and others are reported to have arranged with H. M. Comer, receiver, to rebuild this road and accept in payment the $40,000 of certificates authorized for the work, as noted last week.

Projects and Surveys.

FLORENCE NORTHERN.—Press reports state that interest in this projected road in Alabama is being revived, and that parties have been at Florence with a view to building the road.

KENOVA.—Incorporated in West Virginia to build a railway from Credo, W. Va., to the West Virginia approach of the bridge being built by the Chesapeake & Ohio over the Great Sandy River; capital stock, $10,000; principal office, Kenova, W. Va.; incorporators, J. M. Wingenum, W. H. Trial, W. J. White and F. W. Halsey, all of Philadelphia.

MERIDIAN & TUSCAHOMA.—This company was incorporated several years ago to build a railway from Meridian, Miss., to Tuscahoma, Ala., on the Tombigbee River, about 45 miles. At a recent meeting at Meridian about $25,000 was pledged to aid the road and it is stated that the road will be built for a bonus of $50,000. C. W. Robinson, E. T. George and W. H. Hardy, Meridian, Miss., are interested.

RICHMOND & MANASSAS.—The Virginia state senate has passed the bill granting a charter to this company, noted Feb. 15.

WEST VIRGINIA BLUE LINE.—Incorporated in West Virginia to construct a railway from Rowlesburg,

W. Va., to Shafersford, on Cheat River; principal office at Parsons, W. Va.

Northwest—Existing Roads.

CENTRALIA & CHESTER.—We are indebted to J. McCutcheon, Vice-Pres., Sparta, Ill., for the following information: This company is now operating about 47 miles of railway from Sparta to Centralia, Ill. During the summer the line is to be extended from Sparta to Evansville, 14 miles, the right of way having been given and money raised. Negotiations are now pending with the town of Salem, Ill., to extend the line from Centralia to that place, 11 miles, where connection will be made with the Ohio & Mississippi River, giving Centralia a connection with the county seat of Marion Co. It it also projected to extend the line to Altamont, Ill. An interlocking plant is to be put in at the crossing of the Louisville & Nashville R. R. at Nashville, Ill.

ELGIN, JOLIET & EASTERN.—A press report states that this company contemplates making important improvements in its line. It has been found hard work to haul heavy trains, and either the grades and curves will be reduced or an entirely new route will be taken between Leithton and South Waukegan. Two routes have already been surveyed.

INTERNATIONAL & GREAT NORTHERN.—Plans are being considered for extending this road to Brazoria, a distance of six miles, according to reports.

RED RIVER & SOUTHEASTERN.—A press dispatch from Abilene, Tex., states as follows: This railway is to extend from Henrietta south by way of Abilene and either San Angelo or Ballinger, to a connection with the Southern Pacific at Spofford's Junction. The road was started just before the late panic, and at that time the projectors had already surveyed the entire line and graded several miles, while the road from Henrietta south was ironed for about 20 miles. The Rock Island is suspected of being the moving power behind the scenes, as it is known that several of its Kansas City officials have been for some weeks past quietly buying real estate in this city and county. With this road the Rock Island would be by 650 miles the nearest line from either Chicago or Kansas City to the city of Mexico, and would practically have full control of the cattle shipping of west Texas.

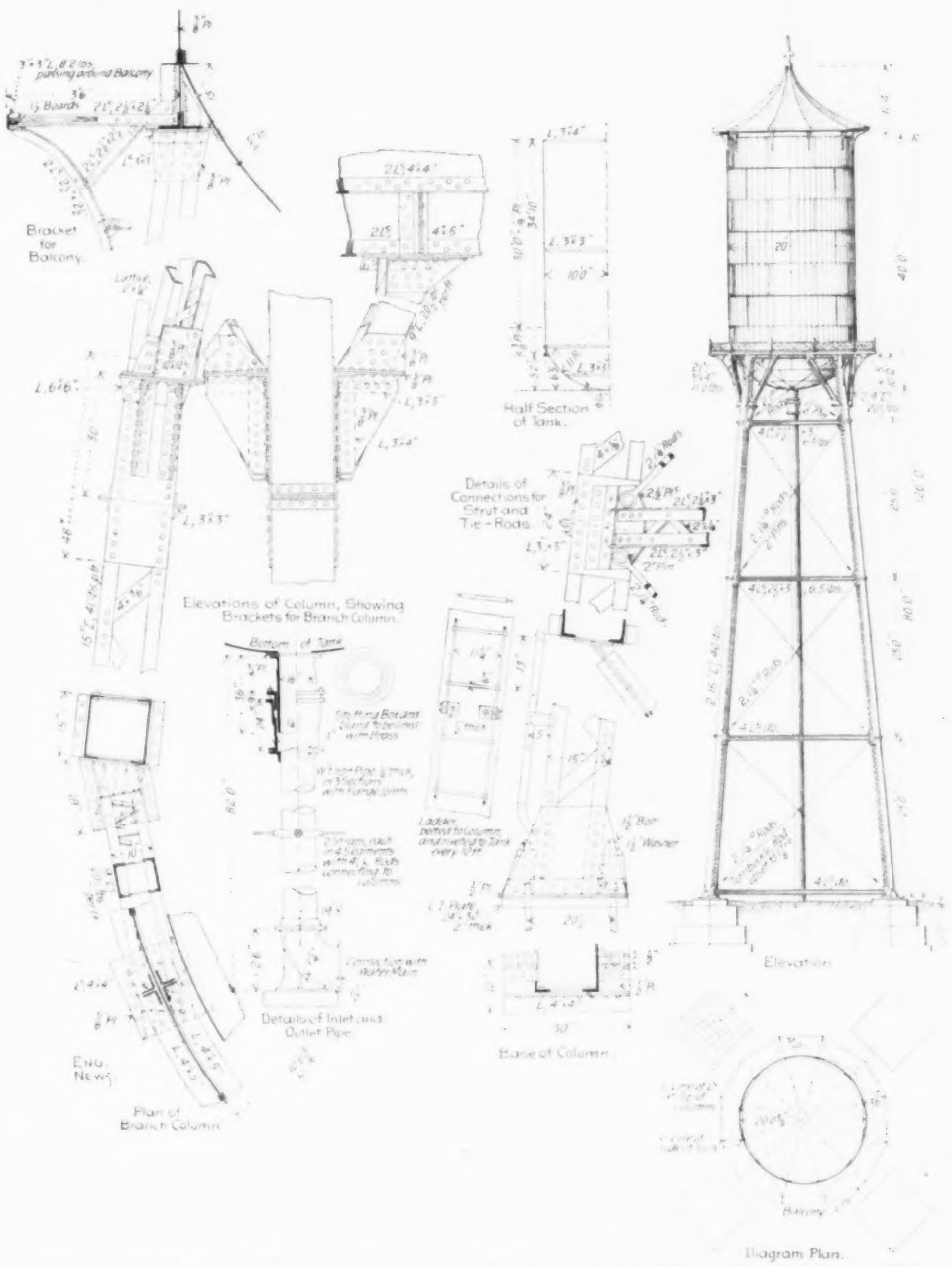

Bracket for Balcony.
Half Section of Tank.
Details of Connections for Strut and Tie-Rods.
Elevations of Column, Showing Brackets for Branch Columns.
Details of Inlet and Outlet Pipe.
Base of Column.
Plan of Branch Column.
Elevation.
Diagram Plan.

FIG. 2. PLAN, ELEVATION AND PRINCIPAL DETAILS OF WATER TOWER, LOREDO, TEX.

ST. PAUL, MINNEAPOLIS & MANITOBA.—A bill has been introduced in the senate granting this company right of way through the White Earth, Leech Lake, Chippewa and Fond du Lac Indian reservations.

Projects and Surveys.

MANITOBA & SOUTHEASTERN.—Efforts are being made at Winnipeg, Man., to secure the construction of this railway from that city to the United States boundary line, and several propositions have been presented to the government on the subject, according to press reports. The company was incorporated several years ago, and Alex. Logan was elected president and Alex. Stewart chief engineer, both of Winnipeg.

Southwest—Existing Roads.

CHOCTAW COAL & RY.—It is reported that a proposition is being considered for building 90 miles of this railway. The company has about 98 miles of road constructed and has been in the hands of receivers for three years.

DENVER & RIO GRANDE.—Ireland Bros., Trinidad, Colo., are reported as having contracted to supply this company with 50,000 broad gage ties for the line between Walsenburg and Garland, Colo., and it is stated that other contracts have been awarded to parties in the San Luis Valley.

TEXAS MIDLAND.—The southern extension of the road to Ennis will be completed within a few weeks and it is reported probable that the construction of the extension from Roberts to Paris will soon be commenced.

Projects and Surveys.

LAKE SUPERIOR, SOUTHWESTERN & GULF.—The contract for building about 400 miles of this railway is reported to have been awarded to the Rosenfield Const'n Co., Omaha, Neb., as stated last week. President Rosenfield, of the construction company, is reported as stating that it is hoped to commence the construction May 1, the contract requiring work to be commenced by Aug. 1. The contracts for ties have already been awarded.

Rocky Mt. and Pacific—Existing Roads.

TACOMA EASTERN.—It is reported that arrangements are being made to resume the construction of this road, which has been graded for about six miles out of Tacoma, Wash. C. B. Wright, Philadelphia, is said to be the chief owner of the road.

TACOMA, LAKE PARK & COLUMBIA RIVER.—Press reports from Tacoma last August stated that $500,000 of bonds had been floated to extend this railway to the Columbia River by way of Cowlitz Pass, and it is now reported that the work may be commenced in the spring. The road extends from Tacoma to Lake Park, about 12 miles.

STREET AND ELECTRIC RAILWAYS.

WATERBURY, VT.—H. M. McIntosh, Cy. Engr., Burlington, is making a preliminary survey for the proposed Mount Mansfield Electric R. R., noted Feb. 22.

ALBION, N. Y.—Wm. Hallock and G. W. Potter are members of the local committee that is considering a proposition of Emmons & Dwyer, New York, for constructing a standard gage electric railway from Batavia to the lake.

NEWBURG, N. Y.—Newburg Electric Ry. Co. has been incorporated; capital stock, $150,000; directors, Geo. L. Nichols, Geo. M. Huyett, W. M. Tobias, H. H. Newkirk, Brooklyn; Harry C. Norton, Newburg, and others.

BRIDGETON, N. J.—A franchise has been granted to the West Side Ry. Co. for an electric railway in Ward 3.

PHILADELPHIA, PA.—It is stated that the plans and specifications for the Conshohocken Electric Ry., which is to be a link between this city, by way of the Roxborough Inclined Plane Ry., and Norristown, have been completed, and that work upon it will soon be commenced. Pres., J. Shepp; Secy., D. B. Shepp. The company has a franchise through Norristown.

READING, PA.—A press report states that the directors of the Mohnsville & Adamstown Electric Ry. Co. have decided to begin work on the line as soon as the weather becomes settled, in order, if possible, to have the road in operation this summer. It is probable that the line will ultimately connect Reading and Lancaster, as there is talk of constructing a line to fill the gap between Adamstown and Lancaster.

CENTREVILLE, MD.—It is stated that surveys will be commenced within a few days for the proposed railway through Queen Anne's county, noted last week.

ELLICOTT CITY, MD.—R. G. H. Carroll, Alex. Brown, S. E. George and Williams & Williams, attorneys, are among the incorporators of a company which proposes to construct an electric railway through Montgomery, Howard and Baltimore counties, to connect Washington and Baltimore; capital stock, $1,000,000.

WASHINGTON, D. C.—G. W. Cissell, R. L. Galt, C. G. Stone and G. W. Harvey are among the proposed incorporators of the Washington, Burnt Mills & Sandy Springs Ry. Co., which has petitioned for a charter to construct a cable or electric railway from Seventh St. west and Florida Ave. to the northeastern boundary line of the District of Columbia.

MANCHESTER, VA.—The state senate has passed a bill incorporating the Chesterfield Transit Co., to build an electric railway from Richmond and this city to Petersburg.

CLEVELAND, O.—It is proposed to extend the Cleveland & Berea St. R. R. through Denison Ave. to Newburg St. and on Newburg St. to Rhodes Ave. in Brooklyn, where direct connection can be made with the Cleveland Electric Ry. Co.'s new branch on Burton St.

OBERLIN, O.—W. B. Gerrish, Engr., writes us that an electric railway through Wellington, Oberlin and Vermillion, 25 miles in length, is under discussion with good prospects of construction. Judge J. W. Steele, Oberlin, is interested.

SPRINGFIELD, O.—Wm. Hanford, former superintendent of the street railway in this city, is reported as at the head of a company which proposes to build an electric railway from this city to Urbana, through Lagonda and New Moorefield.

CHICAGO, ILL.—The North Side Electric Ry. Co. has been granted a franchise for an electric railway on Lincoln Ave., between Wrightwood Ave. and North Fifty-ninth St., and on Milwaukee Ave., between Armitage and Lawrence Aves.

ROCKFORD, ILL.—Three routes for the Rock River Electric Ry., noted Feb. 22, have been surveyed from this city to Oregon and the line is now being surveyed from Oregon to Dixon, by way of Grande Detour and Castle Rock.

WINNIPEG, MAN.—The "Free Press" states that F. W. Colclough, M. P. P. for St. Andrews, expects to leave in a few days for the East in connection with the Selkirk & Winnipeg Electric Ry. Co. He is now the sole owner of this company's charter, and fully expects to be able to form a company in the East to build and operate the line this summer.

ELEVATED RAILWAYS.

PHILADELPHIA, PA.—The ordinance granting a franchise to the Market St., Richmond & Frankford Elevated Electric R. R. Co. has been signed by the mayor, and Theo. W. Cramp, Pres., is reported as stating that contracts for the iron work will be let in a few days. Gen. Man., G. Frederick Keene.

HIGHWAYS.

PENNSYLVANIA.—The citizens of Abington township, Montgomery county, have voted an additional loan of $50,000 for macadamizing the roads, work to be commenced at once. It is stated that all roads leading to railway stations in the township will be macadamized a distance of half a mile from the station, as well as several other leading thoroughfares not reached by the first loan of $80,000.——The contract for constructing a boulevard from Scranton to Elmhurst, 7½ miles, has been awarded to Maier & Lewis, New York. The work is to be commenced as soon as the weather will permit and to be completed by Aug. 1.

BRIDGES AND TUNNELS.

BOSTON, MASS.—Bids are asked until March 10 for building the draw foundation and fender piers for Dover St. bridge, and until March 15 for the steel superstructure. Wm. Jackson, Cy. Engr.

BOSTON, MASS.—We are informed that the contract for building a bridge over Leverett Pond has been awarded by the department of parks to J. D. Fallon & Co., at $9,300; the other bids being as follows, all but two of the bidders being residents of Boston: Melan Arch Const'n Co., New York, $5,000 (not according to specifications); G. M. Atkins & Co., Palmer, $11,900; Walter S. Sampson, $9,848; Jones & Meehan, $9,600; O'Connor & White, $10,653; Leavitt, Daly & Crockett, $9,438; Weaving Booth & Co., $14,475; Johnson Bros., $10,427; John Sutherland, $9,834; H. P. Nawn, $9,800.

BUFFALO, N. Y.—Geo. E. Mann, Ex-Cy. Engr., is preparing a map to be presented with a petition to the council for a bridge across Buffalo River at the foot of Commercial St.

ROCHESTER, N. Y.—The city engineer has prepared plans for the proposed Mortimer St. bridge. The plans call for six arches, total of 224 ft.——Plans are being considered for removing the railway grade crossing at University Ave.; estimated cost of tunnel about $200,000, or of bridge $135,000.

JERSEY CITY, N. J.—A press report states that an agreement will soon be made between the Pennsylvania R. R. Co. and the Hudson Boulevard Co. for bridging the tracks of the Pennsylvania R. R. at Bergen Cut, between Merion and this city. This improvement will consist in a two-span bridge, and will cover the four tracks of the railway at this place.

MONACA, PA.—The Pittsburg & Lake Erie R. R. Co. is reported as about to commence the erection of a double-track trestle bridge over Markey's Run at this place to take the place of the present structure. A heavy fill is also to be made to take the place of the present long and high trestle.

COALBURG, W. VA.—The Cabin Creek bridge on the Chesapeake & Ohio Ry., between this place and Acme, was burned March 2; reported loss, $30,000.

AUGUSTA, GA.—It is stated that a new iron bridge will be built by the Port Royal & Augusta Ry. Co. across the Savannah River about three miles below this city. It will be 808 ft. long, have two fixed spans and a draw span and will cost about $25,000. Supervy. Engr., W. R. W. Howe, Jr. Col. J. H. Averill, Receiver.——A. H. Davidson, Cy Engr., writes us that the plans for the two iron bridges recently noted have not been completed and that the work is only projected.

JACKSONVILLE, FLA.—Roland Woodward, Engr., Jacksonville, Tampa & Key West Ry., has been taking soundings in the St. Johns River at this city and it is reported that J. S. Smith, Jr., J. H. Colvin and J. R. Parrott are interested in a proposed $60,000 bridge soon to be built here.

CHATTANOOGA, TENN.—The entire plans for the Chattanooga Western Ry. bridge over the Tennessee River are to be changed and instead of a high bridge as intended the company will construct a drawbridge. It will be a combination railway, wagon and foot bridge.

CLEVELAND, O.—Efforts are being made to secure a bridge over Rocky River in the southwestern part of the county; estimated cost, $134,500.

INDIANAPOLIS, IND.—The "News" states that steps will soon be taken to construct one or two additional viaducts over the railway tracks.

NORTH INDIANAPOLIS, IND.—The county commissioners have been petitioned to build a new bridge over the canal at Udell St.

MILWAUKEE, WIS.—Bids are asked until March 16 for the superstructure of a folding or rolling lift bridge with two side spans across the North Menominee canal. G. H. Benzenberg, Cy. Engr.

DULUTH, MINN.—The house committee on commerce has favorably reported the bill authorizing the St. Louis River Bridge Co. and Duluth Transfer Ry. Co. to bridge the St. Louis River between Grassy Point, in the village of West Duluth, and the nearest point in Wisconsin.——The committee has also decided to report favorably the bill authorizing the Duluth & Superior Bridge Co. to erect a steel bridge from Rice's to Connor's Point.

RED WING, MINN.—W. E. Taylor, Cy. Clk., writes us that the proposition to issue $70,000 of bonds for the proposed bridge across the Mississippi River was carried over 4 to 1. C. F. Loweth, St. Paul, has been engaged to prepare the plans and superintend the construction.

SOUTH ST. PAUL, MINN.—Press reports state that J. Stewart & Co., St. Louis, have been awarded the contract for the proposed Belt Line bridge at this place, which is six miles from the city of St. Paul. The bridge will be 2,200 ft. long, have four 150 ft. spans and a draw span of 480 ft. It will be operated by the Burlington, the Milwaukee & St. Paul and the Chicago & Kansas City railway companies and will afford a direct entrance to the packing districts of this place. The work has been projected for several years.

YANKTON, S. DAK.—Press reports state that W. J. Waldo, Ch. Engr., and E. E. Reams, foreman of construction, of the Missouri Valley Bridge Co., of Leavenworth, Kan., have commenced making soundings of the Missouri River at this point for a combination railway and wagon drawbridge, which is to be constructed by the bridge company upon a guarantee for its utilization from two railway companies at an annual rental of $16,000. The guarantee has been received and plans for the bridge will be submitted to the secretary of war by June 1. The bridge is expected to cost $250,000 and to be completed Jan. 1, 1896. It is presumed upon authority that the Great Northern will be one of the roads to use the bridge, and that next year that road will be extended into the Southwest.

KANSAS CITY, KAN.—Efforts are being made by residents of Edwardsville, Bonner Springs and other places to secure the construction of the proposed bridge at Turner; estimated cost about $60,000.

HELENA, MONT.—The contract for the iron wagon bridge over the North Fork of Sun River has been awarded to the Wrought Iron Bridge Co. The total bids were published last week.

BRAZORIA, TEX.—It is reported probable that a bridge will soon be built across the Brazos River at this place; estimated cost, $24,000.

HOUSTON, TEX.—The contract for a bridge over White Oak bayou has been awarded to the King Bridge Co., at $6,511.

WINNIPEG, MAN.—It is stated that bids are being received by the board of public works for the erection of masonry piers for a bridge over the Assiniboine River near Boundary St.

HANOVER, ONT.—Bids are asked until March 19 for a steel bridge over the Sangeen River on the Durham road. Jas. Lockie, Deputy Reeve.

TORONTO, ONT.—The Great Northern Ry. Co. is applying for a bonus of $80,000 for a bridge across the Ottawa River at Hawkesbury. Press reports state that it is proposed to connect with the Canada Atlantic, thus forming a new through trunk line from Quebec to Parry Sound and shortening the distance from Duluth to Liverpool by 800 miles. The bridge is estimated to cost $400,000. The Great Northern road is in course of construction under a Federal charter.

WATER-WORKS.

AUBURN, ME.—It is reported that the city is about to purchase 18,000 ft. of 8 to 4-in. and 1,600 ft. of 16-in. pipe.

SEAL HARBOR, ME.—M. G. Tibbetts is interested in a company that is reported as planning to secure a supply from Jordan's Pond, in Mount Desert.

LANCASTER, N. H.—There is talk of purchasing the works.

PETERBORO, N. H.—The estimated cost of proposed works is about $48,000. The question of construction has not yet been settled.

BELMONT, MASS.—The committee appointed a year ago has reported in favor of a supply from the Kendall ponds; estimated cost, $146,707.

ALFRED CENTER, N. Y.—D. R. Stillman, Vil. Clk., writes us that some time ago it was voted to put in works, but investigation showed no adequate supply available and nothing further has been done.

CLYDE, N. Y.—The Clyde Water Supply Co. has sold the works to a syndicate which has acquired control of the plants of Brockport, Medina, Holley and Palmyra, according to press reports. Man., Wm. F. Ross, Rochester.

NIAGARA FALLS, N. Y.—The board of public works has been instructed to ask for bids for the extensions for which $50,000 was recently voted. The work will include 6,000 ft. of 20-in. and 5,861 ft. of 16-in. main.

PENN YAN, N. Y.—An election will be held March 8 to vote on the construction of works; estimated cost, $60,000.

BAYONNE, N. J.—It is reported that bids will soon be received for extensions estimated to cost $16,000.

HADDONFIELD, N. J.—It is reported that the water company is about to extend its service to Collingswood.

IRVINGTON, N. J.—The commissioners of Newark have voted to supply this place with water for ten years, at 12½ cts. per 1,000 gallons.

JERSEY CITY, N. J.—Geo. F. Bouton, Clk., informs us that the following bids were received for furnishing and laying 18,500 ft. of 16-in. cast iron pipe, with branches, nine 12-in. gates, etc.: P. J. Condon, $21,413; Geo. Clarke, $23,971; Henry Byrne, $24,097; James J. Harrington, $24,150; John Hopkins, $25,614; Inman Bros. Construction Co., $26,555; Edward O'Neill, $26,546; G. A. Judge, $26,765; John J. Shea, $29,158; Geo. Keise $58,870.

NEWARK, N. J.—Bids are asked until March 14 for about 30,000 ft. of 6-in. cast iron pipe. Chas. Marsh, Supt. Wks.

RIDGEWOOD, N. J.—Press reports state that the Crystal Springs Water Co. has been incorporated, with a capital stock of $50,000, by E. E. Burtis, J. B. Lydecker, J. W. Miller, Geo. Halstead, D. B. Burtis and others, to lay a 12-in. main from Hohokus township line to this place. A reservoir is to be situated west of the Allendale station, at an elevation of 175 ft. Waldwick, Hohokus and Undercliff are also included in the project.

SOUTH ORANGE, N. J.—The South Orange Heights Water Co. has been incorporated by E. W. Cooper, R. G. Hazeldine, C. G. Fielding and others; capital stock, $10,000.

WILDWOOD, N. J.—It is stated that works will be put in.

MEADVILLE, PA.—W. A. Doane, Cy. Engr., has reported that entirely new works can be constructed for $113,513. The water company offers to sell its plant for $182,000.

READING, PA.—The council is considering ordinances appropriating $35,000 for an additional pumping engine and repairs at Maiden Creek and $15,000 for an auxiliary pumping station and stand-pipe at Hampden reservoir.

ST. CLAIR, PA.—The Butcher Spring Water Co. has been incorporated; capital stock, $2,000. Treas., Geo. E. Phillips, 4,037 Green St., Philadelphia.

TOWER CITY, PA.—C. M. Kaufman, Pres., Citizens' Water Co., writes us that works will be constructed as soon as possible in the spring, but that the specifications have not yet been completed; supply from mountain stream; population, 5,000.

MARTINSVILLE, VA.—W. S. Penn, Clk., writes us that the contract for works has been awarded as stated last week; supply from creek; population, 2,500.

WINCHESTER, VA.—The citizens have voted, 688 to 18, in favor of an additional supply.——Press reports state that the city has received a gift of $30,000 toward the work, which is estimated to cost $32,890.——The work will be advertised in our issue of next week, bids to be received until April 3. Engr., Alexander Potter, New York.

AIKEN, S. C.—W. G. Chafee, Mayor, writes us that the citizens have voted to issue $50,000 of bonds for works, and that bids will be received for the construction as soon as the bonds have been sold.

GEORGETOWN, S. C.—W. D. Morgan, Mayor, is reported as wishing to correspond with parties relative to a franchise.

JACKSONVILLE, FLA.—Bids are asked until April 5 for $1,000,000 of 5% bonds, recently voted for waterworks and other improvements. Geo. R. Foster, Chn.

DEMOPOLIS, ALA.—The council wishes to grant a franchise for works, according to reports.

CARTHAGE, O.—It is reported probable that an election will be held to vote on an appropriation of $7,000 for a reservoir.

ST. BERNARD (P. O., Ludlow Grove), O.—Bids are asked until April 5 for $85,000 of 20-year 5% bonds, recently voted for works and electric lights. J. G. Opermann, Clk.——Bids for the construction will be received as soon as the bonds have been sold.

STEUBENVILLE, O.—The council has voted to submit the question of issuing $175,000 of bonds for the construction of new works to the voters at the spring election.

TOLEDO, O.—H. C. Cotter, Supt., writes us that the question of extensions has not yet been decided upon, but is being considered.

WAPAKONETA, O.—The council has engaged J. P. Martin, Xenia, on the following terms: 1½% of the cost of construction, for revising plans and specifications, constant attendance of assistant and weekly inspection by himself, also for preparing advertisements, supervising award of contracts, etc.

YOUNGSTOWN, O.—F. M. Lillie, Cy. Engr., writes us that the council has voted to submit the question of issuing $186,000 of bonds to extend the works to a vote of the people at the spring election.

LAFAYETTE, IND.—W. H. Caulkins, Secy. water company, writes us that the contract for steel tank five miles of pipe, wells, etc., has been awarded to J. O. Heater, Junction City, Kan., and that the contract for the remainder of the plant will probably be awarded in the summer.

BATAVIA, ILL.—Bids are asked until March 17 for constructing works, as stated in our advertising columns. H. B. Bartholomey.

BUSHNELL, ILL.—The item in our issue of last week regarding this place referred to Rushville, Ill.

GIRARD, ILL.—The council has voted to contract for a supply, at $2,000 a year for 34 hydrants, works to be in operation by next October, according to reports.

OTTAWA, ILL.—W. S. Reed & Co., The Rookery, Chicago, have been awarded the contract for works. Supply will be from artesian wells and works will include a 500,000-gallon reservoir, about 20 miles of 16 to 4-in pipe, 150 hydrants, stand-pipe, etc., as stated last week.

RUSHVILLE, ILL.—W. S. Shields, Title and Trust Bldg., Chicago, has been engaged to design and superintend the construction of works.

WAUKEGAN, ILL.—Henry Thacker, Cy. Clk., writes us as follows: The city council has passed an ordinance for a system to be constructed by special assessment, at a cost of $70,500, to be added to the seven miles of pipe now in the streets, which are supplied from artesian wells. This system cannot be commenced until the assessment is made and confirmed by court, which may or may not ever be done. Court meets in April.

MAZOMANIE, WIS.—J. A. Schmitz, Vil. Pres., writes us that the works are completed except an extension of 2,600 ft. of 6-in. pipe and the construction of a 60 × 20 × 10-ft. reservoir, which work will be done early in the spring.

ONALASKA, WIS.—Bids are asked until March 22 for works, as stated in our advertising columns. Consult. Engr., Chas. F. Loweth, St. Paul.

BROOKLYN, IA.—The question of works will soon be voted upon, according to reports.

GRUNDY CENTER, IA.—E. E. Ensminger, Vil. Recorder, writes us that plans or specifications have not yet been prepared for the proposed works; population, 1,500.

ALDEN, MINN.—Peter Hansen, Vil. Recorder, writes us that the question of works will be voted upon March 13 and that nothing will be done till after that date.

ELBOW LAKE, MINN.—It is reported that an election will be held to vote on an issue of $60,000 of bonds for works.

ST. CHARLES, MINN.—T. H. Botham, Winona, is preparing plans for new works, according to reports, including 13,500 ft. 8 and 9-in. pipe and 20 hydrants; estimated cost, $11,980.

HASTINGS, NEB.—W. W. Miles, Cy. Clk., writes us that the question of issuing $10,000 of bonds for extensions will be voted upon April 3.

TOBIAS, NEB.—It is reported probable that an election will soon be held to vote on the question of works.

SIOUX FALLS, S. DAK.—A committee has been appointed to choose appraisers to decide upon the value of the works with a view to the purchase of the same by the city.

BETHANY, MO.—The citizens have voted to issue $30,000 of bonds for works and electric lights.

ODESSA, MO.—E. F. Blake, Mayor, writes us that he is getting estimates on a small plant to lay the question of works before the council.

RICHMOND, MO.—J. L. Farre, Jr., Mayor, writes us that the question of works has not yet assumed definite shape; supply, pumped, two miles distant; population, 3,500.

BAIRD, TEX.—Bids are asked until March 14 for constructing works. Designing engineer, Frank E. Snyder, Austin, Tex. J. E. W. Lane, Mayor.

BASTROP, TEX.—The Bastrop Water & Light Co. has been incorporated by P. O. Elzner, T. A. Haslis and others; capital stock, $40,000.——F. H. De Long, Pres., writes us that the contract for works has been awarded to W. E. De Long, at $26,000, work including 14 × 110-ft. stand-pipe and a duplex pumping engine; supply from Colorado River; population, 3,500.

SHERMAN, TEX.—Low McKown, Supt., writes us that a small reservoir will probably be constructed and the mains extended in the near future; supply from deep wells with air lift pumps.

CENTRAL CITY, COLO.—Press reports state that the supply in this city and Black Hawk is inadequate and that efforts are being made to increase it.

PORTLAND, ORE.—The construction of the new reservoir for which bids will soon be received, as noted last week, will require 61,500 cu. yds. of earth, 15,000 cu. yds. of loose rock and 35,500 cu. yds. of solid rock excavation and the construction of 4,100 cu. yds of embankment.

COLTON, CAL.—The Colton City Water Co. has offered to sell its plant to the city for $40,000.

OCEANSIDE, CAL.—The proposition to issue $30,000 of bonds for a pumping system has been defeated and it is stated that a gravity supply from the San Luis Rey River at Pala is favored.

MONTREAL, QUE.—The committee has requested $116,000 for extensions.

VERNON, B. C.—R. J. Davies, Cy. Clk., writes us that the question of works is only in the preliminary stage of contemplation.

ARTESIAN WELLS.

PIERRE, S. DAK.—The board of trade is raising $5,000 to secure another well.

CORSICANA, TEX.—The commercial club is advertising for bids for a private company to sink three artesian wells for public water supply; neighboring well is 2,300 ft. deep.

BURNS, ORE.—It is reported that an artesian well will soon be sunk.

IRRIGATION.

NEW MEXICO.—It is stated that $50,000 will be appropriated by congress for building irrigating ditches for the Navajo Indians in western New Mexico.

LANDER, WYO.—The "Gazette" states that there is another large ditch under contemplation, supply from Little Popo Agie, and which will furnish water for a large tract of land between the Little and Big Popo Agies, now useless. It is proposed to fill the dry lake southeast of this city and use it as a reservoir.

NEW COMPANIES.—Artesian Water Supply Co., Los Angeles, Cal.; $200,000; to buy and sell water, to develop water by ditches, canals, etc.; R. Day, A. G. Blaisdell, D. S. Diffenbacher, W. S. Clark.——Drury Land & Irrigation Co., Greeley, Colo.; $500,000; Wm. Drury, D. A. Canfield, Wesley Valentine.——Gila River Irrigation Co., Silver City, N. Mex.; $100,000; M. W. Neff, Decatur Neff, A. J. Loomis, D. B. Claypool.

SEWERS.

LANCASTER, N. H.—The question of a system is to be voted upon at the town meeting this month.

MEDFORD, MASS.—The committee has asked for an additional appropriation of $1,000 for surveys and plans for the proposed system. J. D. Street, C. H. Parker, J. W. Rockwell, Committee.

SPENCER, MASS.—N. E. Craig, Tn. Engr., will recommend the intermittent downward filtration system of sewage disposal, according to reports.

SPRINGFELD, MASS.—The city engineer has estimated that about $30,000 will be needed for building sewers not including a proposed sewer in Ward 1, which is estimated to cost $30,000.

EAST GREENWICH, R. I.—The citizens are petitioning the council for a system.

WOONSOCKET, R. I.—The commissioners are considering the construction of several sewers.

NEW YORK, N. Y.—Bids are asked by the commissioner of street improvement of wards 23 and 24 until March 13 for constructing sewers in several streets.

JERSEY CITY, N. J.—It is reported that bids will soon be asked for building a main sewer in Greenville.

MILLVILLE, N. J.—L. H. Hogite, Cy. Clk., writes us that a franchise has been given to the Millville Sewerage Co. Secy., Colin R. Wise, Passaic, N. J.

NEWARK, N. J.—Ordinances have been passed for pipe sewers in three streets.

BRADFORD, PA.—Bids are asked by the city clerk until March 12 for constructing sewers in the seventh sewer district.

OLYPHANT, PA.—The Olyphant Sewage & Drainage Co. has been incorporated by W. W. Patterson, Wm. Mahon, J. F. Cummings, T. F. Jordan, W. J. Schubmehl, J. J. Cummings, M. J. Lavin and C. P. O'Malley, and has been granted a franchise by the borough council.

PITTSTON, PA.—The Pittston Sewer & Drainage Co. has been formed by J. T. Lenahan, E. F. McGovern, Thos. Dunn, Paul Dunn and P. A. Meixwell, all of Wilkes Barre, to build a system of sewers for this place and West Pittston.

SCRANTON, PA.—Bids are asked until March 15 for constructing 2,150 lin. ft. of sewers. M. T. Lavelle, Cy. Clk.

WASHINGTON, D. C.—Bids are asked by the district commissioners until March 10 for constructing sewers.

CHARLOTTESVILLE, VA.—R. W. Luke, Cy. Clk., informs us that $80,000 has been appropriated for a system which will probably be built this year.

FORTRESS MONROE, VA.—A bill has been passed by the house authorizing an appropriation of $24,902 for constructing a system at Fort Monroe, one half of the cost to be paid by property owners.

CHARLESTOWN, S. C.—T. G. Simons, Chn. Com., writes us that no estimates have yet been completed for the proposed system, noted Feb. 22.

NASHVILLE, TENN.—Bids are being received by the board of public works for sewers in five streets, according to reports.

LOUISVILLE, KY.—Chas. V. Mehler, Ch. Engr., writes us that bids are to be asked about March 15 for 12,000 ft. of 65 to 29-in. brick sewers, average cut 16 ft., estimated cost $50,000, and for 5,000 ft. of 20 to 12-in. pipe sewers, average cut 10 ft., estimated cost $7,500.

BARBERTON, O.—Bids will soon be asked for constructing a system, according to reports.

CINCINNATI, O.—Bids will soon be asked for constructing sewers in 15 streets.——Bids are asked by the board of administration until March 12 for two sewers and until March 14 for one.

CLEVELAND, O.—Bids are asked until March 27 for constructing sewers in seven streets. J. H. Farley, Dir. Pub. Wks.

COLUMBUS, O.—The council has passed an ordinance for a sewer estimated to cost $46,000.——The city has sold $20,775 of sewer bonds.

EVANSVILLE, IND.—Bids are asked until March 17 for constructing two local and two main sewers. E. E. Clarke, Clk. Bd. Pub. Wks.

INDIANAPOLIS, IND.—Bids are asked by the board of public works until March 12 for constructing a 30 to 20-in. sewer 1,649 ft. in length.

ST. JOHN'S, MICH.—D. H. Hunt, Vil. Clk., writes us that the citizens will vote March 19 on issuing bonds for $30,000 to build three miles of pipe sewer outlet.

ROCK ISLAND, ILL.—Bids are asked until March 19 for constructing a pipe sewer. A. D. Huesing, Cy. Clk.

KENOSHA, WIS.—A press report states that Mayor Pettit has published a statement of the expense of constructing the sewer which has just been finished by the town. The cost was several hundred dollars lower than the lowest bid for the contract. Several other sewers will be built before spring.

MADISON, WIS.—It is reported that the city will award a large contract for sewers next summer.

SOUTH MILWAUKEE, WIS.—It is stated that work will soon be commenced on a system to cost $15,000.

HOT SPRINGS, S. DAK.—J. C. Dickover, Cy. Aud., writes us that Walter Scott, Cy. Engr., has prepared plans for 2¼ miles of 12 to 8-in. pipe sewers, average cut 6 to 8 ft., estimated cost $9,000.

HOUSTON, TEX.—A committee has been appointed to investigate an extension of the outlet sewer into the bayou, three miles from the city.

BESSEMER, COLO.—The citizens will vote in April on issuing $35,000 of bonds to build sewers, unless the question of annexation to Pueblo should be favorably voted upon this month.

FORT COLLINS, COLO.—The state agricultural college will receive bids until March 17 for 4,000 ft. of 16-in. sewer pipe.

HINTONBURG, ONT.—F. W. Harmer, Vil. Clk., writes us that the construction of the proposed sewer to the Ottawa River has been indefinitely postponed.

STREETS.

DOVER, N. H.—It is reported that the city has purchased a stone crusher and will macadamize a large number of streets this summer.

FALL RIVER, MASS.—The committee has voted to ask for bids for 14,000 lin. ft. of curbing, and for constructing about 9,000 sq. yds. of concrete sidewalk, according to reports.

MEDFORD, MASS.—The finance committee has recommended that the highway appropriation be increased from $15,000 to $30,000.

SOMERVILLE, MASS.—Horace L. Eaton, Cy. Engr., informs us that it is proposed to pave Somerville Ave. with granite blocks, 5,300 sq. yds., and to reset about 2,100 lin. ft. of granite curbing, at an estimated cost of $20,000, but that the time for receiving bids has not been decided upon.

BROOKLYN, N. Y.—The committee has decided in favor of paving 10 streets with cobblestone, four with asphalt and five with Belgian blocks.

BUFFALO, N. Y.—The lowest bids opened last week for paving eight streets were as follows, the second price in each case being that of W. E. Hingston for a stone pavement: Kensington Ave., Barber Asphalt Paving Co., $165,544, $126,277; Forest Ave., German Rock Asphalt Paving Co., $22,380, $17,122; Central Ave., Barber Co., $15,080, $13,116; Rhine St., Barber Co., $19,960, $14,938; Thomas St., Buffalo Asphalt Co., $12,700, $9,736; Florida St., Barber Co., $12,162; $9,062; Nunda Ave., Barber Co., $18,923, $14,070; Bissell Ave., Barber Co., $20,570, $15,339.

EAST BLOOMFIELD, N. Y.—The citizens will vote on appropriating $1,000 for a stone crusher, according to reports.

NEW YORK, N. Y.—Bids are asked by the department of public works until March 14 for repaving ten streets with asphalt on the present stone block pavement and eight with granite blocks on concrete foundation.——Bids are asked by the commissioner of street improvements of wards 23 and 24 until March 13 for paving one street with granite blocks, also for grading and flagging in one street.

NEWARK, N. J.—The board of works has prepared plans for paving estimated to cost $150,000, and bids will soon be asked for part of the work.

PHILADELPHIA, PA.—Contracts have been awarded as follows: Repairs to sidewalks, $50,000; George A. Vare, Joseph McDonald, M. & J. B. McHugh, Stephen J. Donovan, Joseph McDonald. Repairing streets with macadam, $110,000; J. F. Sharkey, P. McManus, Philadelphia Paving & Const'n Co., Jones & Wallace, Vulcanite Paving Co., George A. Vare, Michael O'Rourke. Paving with granite blocks, $75,000; Thos. Cunningham, Michael O'Rourke. Furnishing and setting out curved granite curb, $40,000; W. S. Stone, Chas. Craig, D. & P. McNichol.

WAYNESBORO, PA.—The citizens have voted to issue $15,000 of bonds for street improvements.

BALTIMORE, MD.—Bids are asked until March 14 for furnishing about 154,000 Belgian blocks, 1,700 lin. ft. of 6-in. curbing and 2,400 lin. ft. of gutter stones. A. E. Smyrk, Cy. Comr.

ALEXANDRIA, VA.—Authority has been asked to issue $200,000 of street and improvement bonds.

ATLANTA, GA.—Bids are asked until March 19 for paving South Pryor St., 18,000 sq. yds., with brick; also for furnishing material and constructing all brick pavements ordered by the council for 1, 2 or 3 years. W. G. Wylie, Comr. Pub. Wks.

ROME, GA.—The council is considering the paving of Broad St.; estimated cost, $35,000.

NEW ORLEANS, LA.—The Bartlett Gravel & Paving Co. has been incorporated with a capital stock of $180,000; Pres., W. H. Cook.

LOUISVILLE, KY.—C. V. Mehler, Ch. Engr., writes us that it is proposed to pave 150,000 sq. yds. with brick, with 75,000 lin. ft of limestone curbing; estimated cost, $650,000. Bids will be received about March 15.

BELLAIRE, O.—It is reported that two squares of Belmont St. will be paved.

CINCINNATI, O.—The board of administration has voted to improve certain streets, estimated to cost $26,484.

MANSFIELD, O.—Bids are asked until March 31 for constructing an arch over Ritter's Run. C. E. Miller, Chn. Com.

SPRINGFIELD, O.—Bids are asked until March 31 for grading and graveling nine streets. S. J. Wilkerson, Cy. Clk.

ST. BERNARD, O.—Bids are asked until March 15 and April 5 for grading and macadamizing one street at each date. J. G. Overmann, Clk., Ludlow Grove P. O.

EVANSVILLE, IND.—Bids are asked until March 24 for paving nine streets with brick. E. E. Clarke, Clk. Bd. Pub. Wks.

MUNCIE, IND.—Press reports state that the council has decided to use asphalt and granite to pave the streets with the coming season instead of brick. The change was the result of public sentiment. The granite blocks will be used only on streets near the depots.

LA PORTE, IND.—Bids are asked until March 26 for paving 15,219 sq. yds. with brick and for 4,373 lin. ft. of sandstone or limestone curbing; estimated cost, $25,000. W. J. Vogt, Cy. Clk.

LANSING, MICH.—The council has authorized the board of public works to purchase a six-ton stone crusher, to cost about $1,300.

CHICAGO, ILL.—The Central Improvement Club of Ward 26 has been incorporated to secure needed improvements in Ward 26; Seth Codeo, T. C. Morse and R. B. Kleeman.

QUINCY, ILL.—E. R. Chatten, Cy. Engr., writes us that bids are asked until March 15 for the 48,000 sq. yds. of brick paving noted in our issue of Feb. 1.

MADISON, WIS.—It is reported that considerable macadam work will be done this summer.

KEOKUK, IA.—It is reported that 10,700 sq. yds. of Main St. will be paved.

ATCHISON, KAN.—H. H. Bayley is a member of a committee that has been appointed to investigate the cost of paving Fourth St. with two layers of brick.

BUTTE, MONT.—The question of paving the streets is again being discussed.

ST. LOUIS, MO.—The board of public works has authorized the reconstruction of Easton Ave. with telford macadam, and the paving of several streets with granite blocks; estimated cost, $185,000.

COLFAX, COLO.—The question of bonding the city for $18,000 for grading sidewalks and electric lights is being discussed.

MONTREAL, QUE.—Bids are asked until March 14 for paving Notre Dame St. with asphalt and scoria blocks. P. W. St. George, Cy. Surv.

ELECTRIC LIGHT AND POWER.

WILMINGTON, VT.—It is reported that an electric light plant will be put in.

PALMYRA, N. Y.—B. H. Davis has been elected president and S. P. Nichols secretary of the Palmyra Electric Light & Power Co., noted last week as incorporated.

SPRINGVILLE, N. Y.—Authority has been asked to establish an electric light plant.

OCEAN GROVE, N. J.—It is reported that $10,000 will be spent this season for better street lighting.

MECHANICSBURG, PA.—Isaac Hugh, Geo. Dyke, A. Z. Myers, B. B. Archer, L. M. Archer and R. J. Bright have organized an electric light, heat and power company and will petition for a charter.

ANNAPOLIS, MD.—The following bids were received for the proposed electric light plant: Pennsylvania General Electric Co., Baltimore, $15,361; C. H. & H. Stanton, Philadelphia, $17,502; J. H. Vail Electric & Mechanical Engineer Co., New York, $21,181; Western Electric Co., New York, $19,851. The Annapolis Gas & Electric Co. offered its entire plant for $150,000. The proposition will be considered March 12.

DEMOPOLIS, ALA.—The city is reported as desiring to grant a franchise for an electric light and waterworks plant.

PADUCAH, KY.—It is reported that the city is intending to buy a plant.

MANSFIELD, O.—Bids are asked until March 13 for lighting the city with gas or electric light for one to three years. W. H. Taylor, Chn. Com.

ZANESVILLE, O.—W. D. Chapman, Akron, is reported as figuring on a new plant for this city.

EVART, MICH.—The citizens will soon vote on issuing $5,000 of bonds for a plant.

MARCELLUS, MICH.—C. W. Thorpe, Little Prairie Ronde, is reported as planning to develop a water power at that place to furnish electricity for power and lighting purposes to this village and Decatur.

DELAVAN, WIS.—An electric light plant will be placed in the pumping station, according to reports.

MONTGOMERY, MINN.—The council has accepted a proposition of J. Quirk & Co. to put in a plant.

GRUNDY CENTER, IA.—Press reports state that an electric light plant will be put in this spring.

OWATONNA, MINN.—The council has voted to put in a plant, both arc and incandescent, in connection with the water-works; estimated cost, $15,000.

BETHANY, MO.—The citizens have voted to issue $30,000 of bonds to put in an electric light plant and water-works.

HIAWATHA, MO.—The city is reported as about to purchase an electric light plant at a cost of about $5,000.

NEOSHO, MO.—The citizens will vote April 17 on issuing $12,000 of bonds for a plant.

ROGERS, ARK.—An electric light plant will be built at once, according to reports.

SEAFORTH, ONT.—Bids are asked until March 10 for the sale of the municipal electric light plant. Wm. Elliott, Tn. Clk.

NEW COMPANIES.—Spearfish Electric Light & Power Co., Chicago, Ill.; $50,000; W. S. Corbin, J. M. Cameron, J. A. Griffin.——Eastern Electric Light, Heat & Power Co., Southampton, N. Y.; $15,000; J. H. Adams, R. P. Roosevelt, Jr., New York; F. S. Tainter, Southampton.

CONTRACT PRICES.

HYDRANTS.—Nashville, Tenn.—The board of public works has awarded a contract for 45 hydrants to the Michigan Brass & Iron Wks., at $19.50 each.

LEAD AND JUTE.—Pittsfield, Mass.—Press reports state that a contract for 20 tons of pig lead has been awarded at 3.3 cts. per lb. and one for a ton of jute rope at 5 cts. per lb.

LEVEE WORK.—Edwardsville, Ill.—The commissioners of the Chouteau levee and drainage district have awarded a contract for 248,000 cu. yds. of work to J. A. Ware, St. Louis, at 7 7-20 to 8⅝ cts. per cu. yd.

ARTESIAN WELLS.—Grand View, S. Dak.—The contract for sinking four 6-in. artesian wells in Douglas county has been awarded to S. Swanson, Minneapolis, at $3.25 per ft., complete, the bidder to furnish everything.

SEWERS.—Newark, N. J.—Contracts for constructing

15-in. pipe sewers have been awarded to Patrick Flynn, at 90 cts. per lin. ft. and $30 for each manhole, and W. J. Hughes, at 85 cts. per lin. ft. and $35 for each manhole.

HALLWOOD BLOCK PAVING.—Mount Vernon, O.—P. P. Chase, Cy. Clk., writes us that a contract for paving with Hallwood blocks has been awarded to the T. B. Townsend Brick & Contracting Co., Zanesville, at $1.60 per sq. yd.; Berea curb, 40 cts. per lin. ft.

BELGIAN BLOCKS.—Baltimore, Md.—Contracts for Belgian paving blocks were awarded last week as follows: S. J. Kemp, 50,000 each at $54.30 and $56 per M. blocks; Wm. Miller, 50,000 at $57.30; Venable Bros., 716,000 at $57.49 and 120,000 at $57; M. Gault & Son, 50,000 each at $56.15 and $59.90; Robt. Mason, 50,000 at $56.40.

DREDGING, Buffalo, N. Y.—The department of public works has opened the following bids for dredging Buffalo River, the Blackwell Canal, Buffalo Harbor and Peck Slip: Hingston & Woods, 14 cts. per cu. yd.; McNaughton & Bapst, 18 cts. for river and canal and 17 cts. for harbor and slip. The work will cost about $8,330.

SEWER BRICK.—Milwaukee, Wis.—The following bids have been secured for supplying the city with sewer brick during the coming season, that of J. R. Ricketson, Chicago, being lower than those of the local bidders for each district:

	East.	West.	South.
Ferdinand Vogt	$8.20	$8.25	$8.00
J. L. Burnham & Sons	8.25	.....	.....
T. W. Saveland	....	7.98	.....
J. Q. Burnham	8.00	8.25	8.05
James R. Ricketson	7.40	7.40	7.40

PUBLIC LIGHTING.—Brooklyn, N. Y.—Public lighting bids for this year were published in our issue of Jan. 25, being practically the same as those of last year. New bids were received last week and the bids for electric lights are $67,787, lower than the previous bids, according to reports, the cost for gas being the same. Instead of 50 cts. a night for arc lights, the Municipal, Edison and Citizens' companies offer the lights at 40 cts. each, while the Municipal company offers electricity at 20 cts. per 1,000 watts, the Edison company offers incandescent lights of 60 c. p. for 20 cts. each a night, and lights of 16 c. p. for 1 ct. an hour. The Citizens' company offers 25 to 75 c. p. incandescent lights at from 10 to 25 cts. a night.

BRICK PAVING.—Lincoln, Ill.—Frank Bollin, Cy. Clk., writes us that the contracts for paving two streets with brick have been awarded to P. Savage. The work consists of 4 ins. sand foundation, layer of brick laid flat, 1 in. sand, course of brick laid on edge and covered with 1 in. sand. The prices were as follows, the bidders being, (1) Patrick Savage, (2) John Cheny, Jr., (3) A. Mayfield, (4) D. Mitchell, (5) D. H. Harts; and the columns A being for Union St., eight blocks, and B being Eighth St., five blocks.

	1.		2.		3.		4.		5.	
	A.	B.	A.	B.	A.	B.	A.	B.	A.	B.
Paving, sq. yd.	$1.14	$1.10	$1.25	$1.25	$1.19	$1.17	$1.15	$1.15	$1.20	$1.25
Curb, p'r lin. ft.	.40	.44	.48	.44	.42	.42	.43	.45		
Blocking, " "	.45	.46	...	.44	...	.40	.43	.44		
Corners, " "	1.18	1.18	...	.95	.40	.90	1.10	.44		

Boone, Ia.—R. M. Mitchell, Cy. Engr., writes us that seven bids were received for about 4,000 sq. yds. of brick paving, two courses, and the contract awarded to the Boone Paving Brick Co., at $1.49 per sq. yd. and

PUMPING ENGINES.—Grand Rapids, Mich.—Fred A. Twamley, Secy. Bd. Pub. Wks., informs us that the following bids were received Feb. 27 for the proposed pumping engines:

	One 10,000,000 gallon.	Two 10,000,000 gallon.	One 15,000,000 gallon.
Frazer & Chalmers, horiz. comp.	$25,000	$44,200	$32,300
Triple expansion	26,500	48,500	34,600
Geo. F. Blake Mfg. Co., comp.	33,000	66,000	54,000
Vertical triple expansion	.....	.....	70,000
Groshon Pump. Eng. Co., vertical triple expansion	43,000	85,000	73,000
Holly Mfg. Co., horiz. comp.	31,250	59,375	53,500
Triple expansion	.....	.....	55,000
Vertical compound	37,600	71,440	53,000
Vertical triple expansion	.....	.....	65,000
A. J. Loretz, vertical compound	39,000	75,000	49,000
Triple expansion	.....	.....	59,000
E. P. Allis Co., vertical comp.	43,000	.....	56,000
Triple expansion	56,000	96,000	70,000
H. R. Worthington, horiz. comp.	25,000	47,500	30,000
Triple expansion	29,000	55,100	38,000
Vertical compound	35,000	66,500	45,000
Vertical triple expansion	39,000	74,100	50,000
Snow Steam Pump Works, horizontal compound	38,000	74,000	50,000
Triple expansion	54,000	106,000	64,000
Vertical compound	42,000	82,000	54,000
Vertical triple expansion	58,000	114,000	68,000

ASPHALT PAVING.—Indianapolis, Ind.—The following bids were received Feb. 26 for paving with Trinidad or equally good asphalt: Talbot Ave., 3,190 ft. long, 27 ft. wide from curb to curb, Western Paving & Supply Co., blue oolitic curb, $5.57 per lin. ft. on each side; stratified limestone, $5.52; Berea, $5.52; Parkhurst curb, $5.52. Warren-Scharf Asphalt Paving Co.; granite curb, $5.87; blue oolitic, $5.66; stratified limestone, $5.58; Berea, $5.58; Parkhurst, $5.58. Fourteenth St., 30 ft. wide, Western Paving & Supply Co., blue oolitic, $6.56; stratified, $6.51; Berea, $6.51; Parkhurst, $6.51. Warren-Scharf Co., granite, $7.09; oolitic, $6.84; stratified, $6.79; Berea, $6.79; Parkhurst, $6.79.

WATER-WORKS.—Waseca, Minn.—Thos. F. McLaughton, Cy. Recorder, informs us that the contract for works has been awarded to E. T. Sykes, as stated last week, and that in addition to the general bid of $27,000 for plan B the following prices are to apply for any increase or decrease in quantities: Cast iron pipe, $20.80 per ton of 2,000 lbs., f. o. b. cars in Waseca; specials, $50 per ton; laying 12, 10, 8, 6 and 4-in. pipe, 34, 31, 28, 26 and 24 cts., respectively; 5 and 4-in. fire hydrants, $38.50 and $34 each, f. o. b. cars; setting each hydrant, $3.50; 12, 10, 8 and 6-in. valves, with valve boxes in place, $36, $29, $23 and $16 each; brick masonry, $11.50 per M brick; concrete, best quality, $3.75 per cu. yd.; concrete for reservoir foundation, $3.25 per cu. yd.; Ideal or Armstrong & Sims engine, $625.

PIPE.—Birmingham, N. Y.—Darwin Felter, Supt., writes us that the city has awarded a contract for supply of 12 to 4 in. cast iron pipe to the Warren Foundry & Machine Co., at average price of $22.30 per ton of 2,240 lbs., delivered.

Albany, N. Y.—G. I. Bailey, Supt., writes us that the contract for cast iron pipe has been awarded to the Warren Foundry & Machine Co., at $21.60 per ton for pipe and 2 cts. per lb. for special castings, total $10,320, the other bids being: Buffalo Cast Iron Pipe Co., $22.40 and 2 cts.; Chas. Millar & Son, $23.40 and 2⅝ cts.; Camden Iron Co., $21.49 and 2 3-10 cts.

Troy, N. Y.—The contract for 1,500 ft. of 12-in. pipe, weighing 75 lbs. per ft., has been awarded to the Radford Pipe & Foundry Co., at $21.84 per ton of 2,240 lbs. for pipe and 2¼ cts. per lb. for special castings, the other bids being: Chas. Millar & Son, $24.50 and 2⅝ cts.; R. D. Wood & Co., $22.50 and 2.45 cts.; Jackson & Woodin Mfg. Co., $22.25 and 2¼ cts.; Donaldson Iron Co., $21.91 and 2¼ cts.; Warren Foundry & Machine Co., $22.20 and 2¼ cts.; McNeal Foundry & Pipe Co., $25.50; F. B. Hawkins & Co., $22.35 and 2¼ cts.; M. J. Drummond, $22.75 and 2⅝ cts.; John Fox, $22 and 2⅛ cts.

Pittsfield, Mass.—The contract for a supply of cast iron pipe has been awarded to the Anniston Pipe & Foundry Co., at $21.50 per ton of 2,240 lbs., delivered in Pittsfield, for pipe, and 2 cts. per lb. for specials. This is said to be $3.05 per ton cheaper than ever before purchased by the city. A. N. French, Clk. Bd. Pub. Wks., writes us that the bids were as follows, the first price being for 12 to 8-in. pipe, the second for 4-in. pipe and the third for special castings.

R. D. Wood & Co.	$22.95	$23.45	2.45 cts.
McNeal Foundry & Pipe Co.	23.25	23.25	2⅝ "
M. J. Drummond	22.75	24.20	2¼ "
Warren Foundry & Mach. Co.	22.70*	23.80	2¼ "
Chas. Millar & Son	24.50	25.50	2⅝ "
Jackson & Woodin Mfg. Co.	22.58	22.58	2¼ "
Howard Harrison Iron Co.	24.92	24.92	2⅝ "
Donaldson Iron Co	23.36	25.36	2⅝ "
Radford Pipe & Foundry Co.	21.75	21.75	2¼ "
Anniston Pipe & Foundry Co.	21.50	21.50	2 "

*$23 for 8-in.

MISCELLANEOUS CONTRACTS AND SUPPLIES.

STEAM ROLLER.—Waltham, Mass.—The aldermen have appropriated $4,000 for a steam roller.

STREET CLEANING.—The board of public works will receive bids until March 14 for sweeping paved streets.

COURTHOUSE.—Brazoria, Tex.—Bids are asked until March 27 for constructing a courthouse. W. S. Bittel, Co. Judge.

EXCAVATION.—Sandusky, O.—Bids are asked for excavating 25,000 to 50,000 cu. yds. of earth in gypsum quarries at Gypsum. Marsh & Co.

SCHOOLHOUSE.—Cheviot, O.—Bids are asked until March 26 for building a shoolhouse at Dent, Green township. E. P. Jackson, Clk. Bd.

CANAL IMPROVEMENTS.—Kearney, Neb.—An election will be held April 3 to vote on an issue of $60,000 of bonds to the Kearney Canal Co. for the improvements noted last week.

OFFICE BUILDING.—Chicago, Ill.—It is stated that contracts will soon be awarded for the steel and terra cotta for a 14-story office building to be erected at the corner of Jackson and Washington Sts. Estimated cost, $300,000. D. H. Burnham, Architect.

DAMS.—Duluth, Minn.—The secretary of war has granted to the Almonte Water Co., of Duluth, the right to erect dams in the St. Louis and Cloquet rivers for the purpose of increasing the navigability of those streams and creating a reservoir to furnish water and water power for this city and other places. The incorporation of this company by Thos. Kneeland, Minneapolis, and others, was recently noted.

CHAMBER OF COMMERCE BUILDING.—Detroit, Mich.—Press reports state that the contract for constructing the new chamber of commerce building, 12 stories high, has been awarded to Benj. Hyde, Chicago, $415,000. The contract calls for a steel skeleton building with stone and brick masonry walls. The work is to be commenced April 15 and completed March 15, 1895. Architects, Spiers & Rohns, Detroit.

NOTICE TO CONTRACTORS.

FRANKFORT, N. Y., WATER-WORKS.

Sealed proposals will be received by the Board of Water Commissioners of the village of Frankfort until 12 o'clock noon of March 31st, 1894, for the construction of water-works. The works will be divided into two sections, as follows:

First—The supply system, comprising the furnishing and laying about two hundred and fifteen net tons of cast iron pipe, from 4 to 16 inches in diameter, furnishing and setting about two net tons of special castings, about twelve valves and about one air valve and about six valve boxes.

Second—The distributing system, comprising the furnishing and laying of about five hundred and twenty net tons of cast iron pipe, from 2 to 12 inches in diameter. The furnishing and setting of about nine and one-half net tons of special castings, about forty double nozzle hydrants, about forty-five valves and about forty-five valve boxes.

Bids will be received for either or both of the above sections. Plans can be seen and specifications secured at the office of the Board of Water Commissioners at Frankfort, N. Y., on and after March 12th, 1894.

The Board of Water Commissioners hereby reserve the right to reject any and all bids or to accept any that in their judgment will be for the best interests of the village.

Bonds satisfactory to the Board in amount and sureties will be required of those to whom the contract may be awarded. The sureties shall be residents of the state of New York or a trust company organized under the laws and doing business in the state of New York.

Each bidder will be required to state in his proposal the names and addresses of his bondsmen.

Cash or a certified check, made payable to the Board of Water Commissioners of Frankfort, N. Y., to the amount of $250 for each section, must accompany each bid as a guarantee that, in case the contract is awarded, the successful bidders will, within ten days after notification of award, execute said contract.

Bids must be sealed and addressed to Thomas Honohan, secretary of the Board of Water Commissioners, Frankfort, N. Y., marked "Proposals for Water-Works."

Signatures of Board,

GEORGE A. SMITH, President.
THOMAS HONOHAN, Secretary.
T. P. FARRELL, Treasurer.
W. D. ALLEN.

THE STANWIX ENGINEERING COMPANY.
Rome, N. Y., Engineers.
10-1t

SEWER PIPE AND CEMENT.

Proposals will be received until March 15th, 1894, 7 o'clock p. m., for furnishing 30,000 feet of sewer pipe and 6,000 barrels of cement. For specifications and further particulars address G. A. WETHERBEE, City Engineer, Malden, Mass. 10-1t

LEBANON, IND., WATER-WORKS.

SEALED PROPOSALS WILL BE RECEIVED until 2 o'clock p. m. of THURSDAY, March 15, 1894, by the City Council, for the following items for the Lebanon, Ind., Water-Works:

Seven hundred and fifty-two (752) tons of cast iron water pipe from four (4) to twelve (12) inches diameter.

Thirty-eight thousand (38,000) pounds of special castings for above pipe.

Ninety-three (93) double nozzle fire hydrants.

Seventy-nine (79) stop valves, and seventy-nine (79) stop boxes for above pipe.

Laying of above pipe and setting of above special castings, fire hydrants, stop valves and stop boxes.

One brick pumping station and brick chimney.

The driving and connecting together of a system of driven wells.

Two (2) compound condensing duplex direct-acting pumping engines, each of seven hundred and fifty thousand (750,000) gallons nominal daily capacity, together with two (2) return tubular boilers and all appurtenances necessary to complete said machinery.

One steel stand-pipe and masonry pier.

Proposals must be made on the blank forms furnished by the City Council of Lebanon, Ind., and all legal formalities must be complied with to secure consideration of proposals. The preliminary bonds and date of furnishing materials and completion of work must be filed to constitute a formal proposal.

Plans of above work may be examined and blank forms of proposal and specifications can be obtained at the office of the City Council, Lebanon, Ind., or the office of the Engineer, 35 and 36 Glenn Building, Cincinnati, O.

The proposals must be sealed and addressed to the City Council and be indorsed by the name of the person, firm or corporation which makes the tender, and be accompanied with a certified check payable to the order of the City Clerk, as follows:

Water pipe and special castings	$500.00
Fire hydrants	300.00
Stop valves	200.00
Pipelaying	200.00
Pumping station and chimney	200.00
Pumping machinery	300.00
Stand-pipe	200.00
Pier for stand-pipe	200.00

The City Council reserves the right to reject any or all proposals.

JESSE NEFF,
J. M. BECHTELL,
GEO. W. CAMPBELL,
E. D. BUSBY,
N. HAZELRIGG,
G. F. L. ESSEX,
Committee on Water-Works.

JOHN W. HILL, Engineer, Cincinnati, O.
Lebanon, Ind., Feb. 19, 1894. 9-2t